ANALYSIS OF CORPORATE SOCIAL RESPONSIBILITY REPORTING OF CLASS I RAILROAD COMPANIES OPERATING IN THE US

by

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I dedicate this dissertation to my mother, who gave me invaluable support and encouragement over the years.

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GLOSSARY

Criteria Air Pollutants: Pollutants for which either the US Federal or the California Government have established air-quality standards because of their effects on human health (O'Rourke et al., 2012). There are six criteria air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2) lead (Pb). Volatile organic compounds (VOCs) although not criteria air pollutants are often considered part of the criteria air pollutants. Hydrocarbons (HC) are part of the VOCs (O'Rourke et al., 2012). Emissions of these gases are considered to be dependent to the engine's characteristics rather than on the type of fuel used.

- **CO:** Carbon Monoxide. A criteria air pollutant. CO is present in the atmosphere in small quantities naturally and due to human activity. CO can be created by internal combustion engines (i.e., locomotives). Locomotives' emissions of CO are regulated by the EPA.
- **NOx:** Nitrogen Oxides, a criteria air pollutant and also classified as an indirect GHG. Locomotives' emissions of NOx are regulated by the EPA.
- **O_3:** Ozone. Ozone is a GHG present in two layers of the Atmosphere. When present on the higher layer (stratosphere) it is considered good, as it shields the earth from some of the sun's ultraviolet light. When present in the lower layer (troposphere), ground-level ozone is considered a harmful gas, as it can cause several respiratory illnesses to humans (U.S. EPA, 2007). Additionally, ground level ozone acts as a greenhouse gas (Stocker et al., 2013).
- **$PM_{2.5}$ and PM_{10}:** Particulate matter. PM refers to a mixture of solid particles and liquid droplets present in the air. Some of them can be dirt, dust, soot or smoke. **PM_{10}** refers to particles that have a diameter of 10 micrometers and smaller and **$PM_{2.5}$** are particles with diameters of 2.5 micrometers and smaller (in comparison the average human hair is 70 micrometers in diameter) (U.S. EPA, 2018b). Locomotives' emissions of $PM_{2.5}$ and PM_{10} are regulated by the EPA.
- **SO_2:** Sulfur Dioxide, a criteria air pollutant. Emissions of SO_2 are dependent on the Sulphur content of fuel (Johnson et al., 2013).

- **VOCs:** Volatile organic compounds, referred as hydrocarbons. Criteria air pollutants. VOCs are precursors of ground-level ozone (U.S. EPA, 2018a). Ground level ozone acts as a greenhouse gas (Stocker et al., 2013).
- **HC:** Hydrocarbon. Although not listed as a criteria air pollutant, locomotives' emissions of HC are regulated by EPA.

GHG: Green House Gas. GHGs trap heat in the atmosphere causing an increase of the earth's temperature (U.S. EPA, 2018b). GHGs are present in the atmosphere naturally and by human activity. The primary GHGs present in the atmosphere in order of quantity are: water vapor, carbon dioxide (CO_2), nitrous oxide (NO_2), methane (CH_4) and ozone (O_3) (IPC 4th Assessment report, Glossary). There are also four categories of GHGs that are entirely human-made: sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3) (U.S. EPA, 2018b).

- **Water Vapor:** A GHG present in the atmosphere naturally and due to human activity.
- **CO_2:** Carbon Dioxide, a GHG present in the atmosphere naturally and due to human activity. Its concentration due to human activity has increased significantly during the past 200 years.
- **NO_2:** Nitrous Oxide, part of the Nitrogen Oxides and a GHG. NO_2 primarily gets in the air from the burning of fuel (U.S. EPA, 2018b).
- **CH_4:** Methane, a GHG part of the Hydrocarbons (HC). Methane is present in the atmosphere naturally and due to human activity.
- **O_3:** See above.
- **SF_6:** Sulfur Hexafluoride. Human created GHG, it is considered potent GHG having high global warming potentials and long atmospheric lifetime. SF_6 accumulation is irreversible once emitted (U.S. EPA, 2018a).
- **HFCs:** Hydrofluorocarbons. Human created GHGs, they are considered potent GHGs having high global warming potentials and long atmospheric lifetimes. Their accumulation is irreversible once emitted. However, HFCs do not deplete the Ozone layer (U.S. EPA, 2018a).
- **PFCs:** Perfluorocarbons. Human created GHG, they are considered potent GHG having high global warming potentials and long atmospheric lifetimes. Their accumulation is

irreversible once emitted. However, PFCs do not deplete the Ozone layer (U.S. EPA, 2018a).

- **NF_3:** Nitrogen Trifluoride. Human created GHG, they are considered potent GHG having high global warming potentials and long atmospheric lifetimes. Their accumulation is irreversible once emitted (U.S. EPA, 2018a).

Indirect GHGs: Indirect greenhouse gases. This group of gases do not have the same global warming effect as GHGs, however they contribute indirectly to the planet's temperature increase by affecting the behavior of other gases such as O_3, and SO_2 (U.S. EPA, 2018a). Indirect greenhouse gases include: carbon monoxide (CO) and nitrogen oxides (NO_x and NO_2), VOCs and SO_2 (U.S. EPA, 2018a).

NH_3: Ammonia is a fuel for motor vehicles composed of nitrogen and hydrogen. It is sable and colorless with a distinctive smell. Ammonia has been considered an alternative fuel since the 1940s ("Amonia Energy Association," 2019).

Line-haul locomotives: There are two different types of railroad operations part of Class I railways: line-haul and switching. Line-haul locomotives are used for long-distance, interstate movement of cargo. Line-haul locomotives have engines of 2,301 horsepower or more (40 CFR § 1033.901). The operational difference between the two modes is the power levels in which they function. From 8 throttle notch modes, line-haul spends a high percentage of the time in the high power notches, specifically in notch 8 (Starcrest Consulting Group, 2008).

Switching locomotives: refers to locomotives used for assembling, disassembling trains, car-sorting for subsequent delivery to terminals at various locations in and around a port (Starcrest Consulting Group, 2008). Switcher locomotives as defined by the EPA, have engines between 1,006 and 2,300 horsepower. From its operational power levels, the switch operation involves much time in idling and spends most of its time in the low power notches (Starcrest Consulting Group, 2008).

LIST OF ABBREVIATIONS

AAR: Association of American Railroads

ARB: California Air Resources Board

BNSF: Burlington Northern Santa Fe Railway Company (Class I Railroad)

BTS: United States Bureau of Transportation Statistics

Caltrans: California Department of Transportation

CAA: Clean Air Act

CARB: California Air Resources Board

CDP: Carbon Disclosure Project

CN: Canadian National (Class I Railroad)

CP: Canadian Pacific (Class I Railroad)

CR: The Climate Registry

CSR: Corporate Social Responsibility

CSX: CSX Corporation (Class I Railroad)

DOE: United States Department of Energy

DOT: United States Department of Transportation

EPA: United States Environmental Protection Agency

FRA: United States Federal Railroad Administration

FRF: Freight Rail Framework (Proposed)

GRI: Global Reporting Initiative

GWP: Global Warming Potential

ICC: Interstate Commerce Commission 1887 – 1995

IPCC: Intergovernmental Panel of Climate Change

KCS: Kansas City Southern (Class I Railroad)

LNG: Liquefied Natural Gas (An alternative fuel)

LSP: Logistics Service Provider

LTSS: GRI Logistics and Transportation Sector Supplement

MoU: Canadian Memorandum of Understanding

NS: Norfolk Southern (Class I Railroad)

NSFT: National Freight Strategic Plan

PSR: Precision Scheduled Railroading

SASB: Sustainability Accounting Standards

SEC: United States Securities and Exchange Commission

STB: Surface Transportation Board operating since 2015. Previously the ICC

UP: Union Pacific (Class I Railroad)

ABSTRACT

There were three objectives in this study. First, it was to identify which indicators Class I Rail companies reported in their Corporate Social Responsibility (CSR) reports to become sustainable. Second, to identify which indicators Class I Rail companies implemented to reduce emissions and increase capacity. Third, to identify if company size or government legislation/support affected the environmental reporting of Class I Railroad companies.

For the first objective, reports filed by companies to the Global Reporting Initiative (GRI) were analyzed. It was found that companies reported mostly on social indicators related to employee wellbeing, followed by environmental indicators related to finding ways to reduce emissions caused during transportation. For the second objective, a framework was developed by the researcher, the Freight Rail Framework, which included indicators to measure capacity increase and emissions reduction efforts. Reports from the GRI and the Carbon Disclosure Project (CDP) filed by companies were analyzed. Results showed that companies relied mostly on locomotive technological improvements to reduce their emissions. However, although not mentioned directly in the reports, many of the indicators related to capacity increase were also implemented. Finally, from factors that could have been affecting the reporting and therefore initiatives companies were implementing to reduce their environmental impacts, it was government legislation/support which was found to have an effect in the reporting and practices implemented by Class I Railroad companies.

CHAPTER 1. INTRODUCTION

In the first chapter, a summary of the research, motivation of the study, scope, significance and research questions are mentioned. In the second chapter, background, useful data related to Class I Railroads operating in the U.S., types of air emissions caused by rail and legislation to control emissions are described. In chapter three a literature review with definitions of CSR and sustainability within the rail freight industry was carried out. A review of aspects rail companies can tackle to reduce emissions and to increase their operating capacity were also developed. In chapter four, the methodology was presented; content analysis method was selected to analyze the reports of Class I railroad companies. Finally, in chapter five, six and seven, the results, discussion and conclusions have been presented respectively.

1.1 Introduction

Companies have in recent years have increased the use of Corporate Social Responsibility (CSR) reports to communicate their environmental, economic and social actions to the public (Piecyk & Björklund, 2015b). At the same time, research analyzing companies' CSR reports has become more common as societies' environmental concerns continue to grow. The objectives of such studies have been to identify aspects or indicators companies consider important to be addressed and are implementing to become more sustainable. Additionally, the aim of research has been to identify factors that can be affecting the implementation of indicators, such as customers' pressure, legislation or reducing costs.

Rail is considered one of the least polluting modes available for freight transportation in the U.S. (Brogan et al., 2013). Increasing the use of rail over other modes of transport (air and road) is considered a solution to reduce emissions from the entire freight system (Peris & Goikoetxea, 2016). Increasing rail transport is considered key by researchers because of the pollution caused by the transportation sector and because freight transportation continues to grow. The transportation industry is the economic sector responsible for the highest proportion of Greenhouse Gas (GHG) emissions in the U.S (29% of the emissions) (U.S. EPA, 2018a), and freight is responsible for 18% of those GHG emissions. Additionally, freight transport in the U.S. is growing faster than passenger travel. While passenger miles travelled decreased by 1.4% between 2001 to

2009 (U.S. BTS, 2015), the U.S. Department of Transportation (DOT) estimated that freight tons moving within the nation's transportation network will grow by 40% by 2050.

Although rail is one of the least polluting modes available for freight transport, it is still considered one of the primary consumers of fuel and energy in the U.S. (Saadat, Esfahanian, & Saket, 2016). Most Class I rail locomotives in the US operate with diesel engines, which emit GHG (CO_2, CH_4, N_2O), and air pollutant gases (CO, NO, HC and $PM_{2.5\ \&\ 10}$). The major problem is the emissions of CO_2, a GHG. Greenhouse gases affect climate change by increasing temperature in the atmosphere (IPCC, 2014). Air pollutant emissions are mostly related to affecting the health of populations living along tracks and in close proximity to railyards (Bergin, Harrell, & Janssen, 2012).

In this research, the CSR reporting of Class I railroad companies was studied. Only Class I Railroads were considered because they accounted for most of the rail freight transport in the U.S., with 69% of the freight rail mileage, and 94% of the rail revenue of the country (AAR, 2017). Aspects the rail industry was addressing in their CSR reports to increase their transporting capacity and the actions companies were taking to reduce GHGs as well as air pollutant emissions were identified.

1.2 Statement of the Problem

Findings from previous studies determined that CSR reporting of the logistics industry has not yet reached uniformity (Piecyk & Björklund, 2015b). Researchers have mentioned that there is a lack of understanding of environmental sustainability reporting by Logistics Service Providers (LSP). LSPs offer several services that go beyond only transportation, including: warehousing and purchasing. Additionally, logistics includes several transportation modes (air, road, pipeline, water and rail) (See Piecyk & Björklund, 2015b).

Subsequently, to understand the reporting of the logistics industry, research has indicated the need for narrowing the scope and research in different areas such as: Sector-specific area i.e.: air cargo, road haulage, and warehousing; and transport mode. Research applied to different types of transport operators independently could help researchers to identify common aspects that are considered important for each transport mode to reduce their environmental impact (Lambrechts, Nederland, Turan, Semeijn, & Nederland, 2019; Piecyk & Björklund, 2015b). Therefore in this research, the CSR reporting of the rail freight sector in the US was studied.

1.3 Purpose of the Study

Considering research gaps above mentioned, in this research the CSR reports of Class I railroad companies from the past ten years were analyzed. The purpose of the study was first to identify what indicators companies were reporting to become sustainable. The GRI Logistics and Transportation Sector Supplement from 2006 (current at the time of the analysis) was used as a tool. Second, the purpose of the study was to understand in detail what aspects companies are addressing to reduce emissions while transporting and how companies are addressing capacity increase. For this analysis a specific framework was developed based on the literature review. For this second stage, information from the companies' GRI and Carbon Disclosure Project reports was collected. Finally, the objective was also to identify factors that could be influencing companies' reporting and the actual practices being implemented to reduce emissions or to increase their sustainability.

1.4 Research Questions

The three research questions were related to practices that Class I railroad companies operating in the U.S. were reporting as being implemented to reduce air emissions during freight transportation:

1. What practices have Class I railroad companies reported in their CSR reports during the past 10 years?

2. What practices have Class I railroad companies reported to reduce air emissions and to increase operation efficiency during the past 10 years?

3. What factors appear to be influencing the number of practices being reported by Class I railroad companies to reduce air emissions?

1.5 Significance

Results of the study helped understand how Class I Rail companies in the U.S. were addressing sustainability and more specifically, how the rail companies were preparing for future needs by addressing air emissions reduction and capacity increase. This was important given the current lack of knowledge of how companies that belong to the logistics industry were reporting. Understanding how rail companies reported gave an insight that could be useful for government institutions and other rail freight companies. Government institutions could use the information in the development of policies and government support to continue to reduce transportation's environmental impact and to support companies in their capacity growth. Other smaller rail carriers could also benefit from the information to identify aspects which they can incorporate to become more efficient in their operations and to reduce their environmental impact.

1.6 Scope

The seven Class I railroad companies included in the research were: Union Pacific Railroad, BNSF Railway, Norfolk Southern Railway, CSX Transportation, Kansas City Southern, Canadian Pacific Railway and Canadian National Railway. The research was conducted using publicly available data reported by Class I railroad companies to the GRI, CDP and to the U.S. Securities and Exchange Commission (SEC) in forms 10-K and 40-F.

The researcher focused on two types of emissions: GHG emissions that are of concern for the research community because of their global warming effects, and air pollutant emissions which are regulated by the EPA and that can cause health problems. GHG emissions included were: Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and the human created GHGs; (sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3)). Air pollutant emissions regulated by the EPA and included as part of the study were: Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Hydrocarbon (HC) and Particulate Matter ($PM_{2.5 \& 10}$).

The study included two types of locomotives modalities: line-haul and switching. Line-haul operation refers to the long-distance movement of cargo. Switching operations refers to locomotives that are used for assembling, disassembling trains, car-sorting for subsequent delivery to terminals at various locations in and around a port (Starcrest Consulting Group, 2008).

1.7 Assumptions, Limitations and Delimitations

This study was limited to Class I Railroads that provide service to the 48 contiguous states in the U.S. It was assumed that data provided by Class I railroads in their voluntary reports was reliable. Class II, Class III railroads and Amtrak were not included in the study. Class II and Class III railroads only carry 6 percent of the rail freight revenue of the country and Amtrak did not provide freight transportation service. The study did not consider the emissions of water vapor and ozone, also part of GHGs.

1.8 Summary

Rail is one of the least polluting modes available for freight transportation. Yet, it was still considered to generate high levels GHG and air pollutant emissions which are contributing to global warming and to health problems of the populace. According to previous research, there was little understanding of how railroad companies were approaching initiatives aimed at being sustainable. This study helped fill a research gap by analyzing Class I Railroad companies' CSR and environmental reports. It helped identify actions companies were implementing to be sustainable, to reduce their air emissions and to increase their operations capacity. Also, the impact of two factors: company size and legislation that might have influenced companies to implement those actions were analyzed.

CHAPTER 2. BACKGROUND

In this chapter an overview of Class I rail transportation in the U.S. is given. The chapter started with an explanation of rail transportation within the supply chain industry. Following several characteristics of rail freight transportation in the U.S. were explained including: existing Class I railroads, history of rail freight in the U.S., pollution caused and gasses emitted by Class I railroad companies (greenhouse gases and other pollutants). The chapter finalized with a brief explanation of the existing regulations to control air emissions caused by Class I Railroads.

2.1 Rail Transportation in the Supply Chain and in the Freight Industry

The concept of supply chain management is understood as the management of the flow of materials, information and funds from suppliers to the final assemblers to distribution and then to the consumers (Farooqui, 2010). A supply chain consists of all parties involved in fulfilling a customer's order which can be manufacturers, suppliers, transporters and even the customers themselves (Chopra & Meindl, 2016). Colicchia et al. (2011) identified five stages in a supply chain: 1) inbound supply chain; 2) production (internal supply chain); 3) outbound supply chain; 4) warehousing; 5) product design and use. Freight, and therefore, rail transportation are considered part of outbound supply chain (Colicchia, Perotti, & Melacini, 2011).

Freight transportation refers to goods being transported from one place to another with the use of several modes: truck, rail, water, air and pipeline. Each mode offers different advantages such as price, speed, reliability, accessibility, visibility, security and safety (Grenzeback et al., 2013). Freight transportation is commonly studied at local or urban level and at a global level. Urban freight is defined as the transport of goods within a city's limits; including trips to, out, from, through or within the urban area carried out by light or heavy vehicles (Civitas, 2015). Global freight instead, is linked to global supply chains and considers trips through major ports and includes most transport modes. Global freight transport modes used depend on the management of the supply chains (Ki, Cheung, & Rowlinson, 2011).

Truck and rail are the most common transportation modes used within the U.S. because of advantages related to price and delivery time (Brogan et al., 2013). Trucks dominate the modal share, as 72% of goods tonnage are transported by road, which accounts for 42% of all ton miles and 86% of the commodity value (U.S. DOT, 2019). Rail is the second most used transport mode; transporting 11% of the moved goods that represent 28% of all ton-miles and 4% of the value. The other commonly used transport modes, air and water account for less than 1% and 6% of the goods tonnage, respectively (U.S. DOT, 2019). Rail transportation is the dominant transportation mode when transporting low-value items for long distances. Water transport is also used for the lower value, bulky goods, while air, the fastest transportation mode is used for higher value goods (Brogan et al., 2013). U.S. freight tonnage, percentage of ton-miles and percentage of commodity values are denoted in Table 2.1.

Table 2.1: Freight Transport Modes in the USA

Transport Mode	Percentage of all freight tonnage	Percentage of ton miles	Percent of freight commodity value
Truck	65%	40%	69%
Rail	10%	28%	4%
Water	4%	7%	3%
Air (truck-air)	< 1%	< 1%	3%
Multiple modes & mail	3%	8%	12%
Pipeline	17%	17%	8%
Other & Unknown	1%	< 1%	2%

Adapted from: (U.S. DOT, 2019)

*Data from 2017. Includes total flows: domestic, imports and exports

2.2 Characteristics of Rail Transportation

Rail transportation is a part of the global freight system which is linked to global supply chains (Ki et al., 2011). Rail can be used as the only transport mode of a trip, but mostly it is promoted as a mode that can be used in parts of a trip (multimodal transportation). When analyzing the entire supply chain, rail transportation is seen as a ‘green’ alternative to reduce the emissions from the freight system (See Grenzeback et al., 2013). Rail consumes less energy than most freight transportation modes available and therefore produces less air emissions when transporting goods. Table 2.2 contains the energy consumption of the different freight transportation modes.

Table 2.2: Energy Use of Transport Modes

Transport Mode	**Energy use in British thermal units / ton mile**
Air	30
Truck	4
Water	0.5
Rail	0.4

From: (Brogan et al., 2013)

2.3 Rail Growth in the U.S.

Trains have been used in the United States for almost 200 years for passenger and goods transportation. Some the characteristics of rail growth in the U.S. are: 1) Railroad infrastructure as well as fleet have through history been privately owned and managed; 2) Railroads were the dominant transport mode for people and for goods transport when it was the fastest mode of the time; 3) The use of rail decreased when road became the faster mode; 4) Railroad companies were consolidated as successful transportation service providers after the Staggers Act was established in 1980 (Wolmar, 2012).

Rail lines were first built on the east coast of the U.S. after the arrival of the steam locomotive in the 1830s and slowly continued on to the mid-western and southern states (Wolmar, 2012). Railroads from eastern states were mostly privately financed, while lines from mid-western and southern states were mostly financed by state governments (Wolmar, 2012). A second wave of rail line construction was triggered by the Federal Government after the American Civil War. Private companies received land grants from government to build railroads to connect the existing (eastern) lines across the continent (Meyer, Wagrowski, Keasley, & Reeder, 2010). By 1900 there were 193,000 miles of railroads, and by 1916 the national system had 254,000 miles of railroads (Stover, 1997).

Rail was the most important transport mode in the U.S. during the late 1800s and beginning of the 1900s, but there was a decline of its use at the start of the 20th century. The major reasons were the development of the car industry and the construction of a new highway system heavily funded by the federal government (Wolmar, 2012). Passenger and goods transportation slowly shifted to private cars and trucks respectively. By the 1950s, road transport had become the dominant travel mode. Rail ended up being too expensive for passenger travel since the 1930s, and later on in 1960s, it also became too expensive for freight transport. By the end of the 1970s, rail was used mostly for low-cost freight transportation and rail lines were abandoned at a rate of 15% to 30% in each state. By 1966, rail mileage had dropped from its peak of 240,000 miles in 1916 to 213,000 miles (Stover, 1997).

In 1980 Federal Government issued the Staggers Rail Act which made a difference in the way that railroads were managed. The Act's main objective was to minimize Federal regulatory control in railroads management (Staggers Rail Act of 1980, 1980). Outcomes of the Staggers' Act were visible by the mid-1980s, railroads started to grow and became profitable companies (Stover, 1997). Some of the outcomes were: reduction of the number of railroad companies as a consequence of companies merging. Operations became more efficient, companies reduced the number of workers and loss-making mileage and significantly increased their average trainload with long trains and double decker cars (Wolmar, 2012).

2.4 Existing Rail Freight System

The rail freight system in the U.S. is considered the world's safest, most productive and lowest cost freight rail service. The system is currently composed of approximately 140,000 miles of rail track. There are 610 companies operating in rail freight transportation, and they are classified based on their revenue and operating extent in Class I, II and II railroads (AAR, 2017). Class I railroads is where most of the service and profit is concentrated, they travel across the country and to Canada and Mexico. Class I railroads have an operating revenue exceeding $ 457.9 million. Class II railroads are referred as regional railroads and often operate across several states. Class II railroads have operating revenues between $ 36.6 and $457.9 million. Class III railroads are often referred as short line railroads, and have operating revenues of $36.6 million or less (U.S. FRA, 2020).

There are seven Class I railroads operating in the 48 contiguous States and the District of Columbia (AAR, 2017). Class I railroads account for 69% of the freight rail mileage, they have

90% of the employees and 94% of the rail revenue of the country. Class II and III railroads are smaller operators that vary in size, they can be very small having a few carloads per month to multi-state operators but less than Class I railroads (AAR, 2017). The current Class I railroads, their headquarters location, operation zone and a few financial values are described on table 2.3.

Table 2.3 Class I Railroads Characteristics

Abbreviation / Name	**Name**	**Headquarters**	**Operation Zone**	**Number of States it Crosses**
BNSF	Burlington and Northern and Santa Fe Railway	Fort Worth, Texas	Western States (North & South)	28 US Stated and 3 Canadian Provinces
Union Pacific	Union Pacific Railroad	Omaha, Nebraska	Western States (Central & South)	23 US States
CSX	CSX Freight Trains	Jacksonville, Florida	Eastern States (North & South)	23 US States, DC and 2 Canadian Provinces
CN	Canadian National Railway	Montreal, Canada	Mid-Western States (North & South)	8 Canadian Provinces and 16 US States
KCS	Kansas City Southern	Kansas City, Missouri	Southern Midwestern States	10 US States and 17 Mexican States
CP	Canadian Pacific	Calgary, Alberta, Canada	North, middle States and Canada	13 US States and 6 Canadian Provinces
NS	Norfolk Southern	Norfolk, Virginia	Eastern States (North & South)	22 States and DC

Source: (U.S. SEC, 2019)

2.4.1 Class I Equipment and Infrastructure Variation

Class I railroads operate with locomotives in two modalities:

- Freight line-haul locomotives: used for long-distance, interstate movement of cargo. Line-haul locomotives have engines of 2,301 horsepower or more (Protection of Environment, 2021). Older line haul locomotives have engines of between 2,000 - 3,000 hp, and newer locomotives have engines between 3,500 - 5,000 hp (O’Rourke et al., 2012).
- Switching locomotives: used for assembling, disassembling trains, car-sorting for subsequent delivery to terminals at various locations in and around a port (Starcrest Consulting Group, 2008). Switcher locomotives are the least powerful locomotives, they have engines between 1,000 and 2,300 horsepower (Protection of Environment, 2021).

The operational difference between line-haul and switcher locomotives is the power levels at which they function. From 8 throttle notch modes, line-haul spends a high percentage of the time in the high power notches, specifically in notch 8. The switch operation, instead, spends involves a lot of idling time and spends most of its time in the low power notches (Starcrest Consulting Group, 2008).

2.4.1.1 Infrastructure and Facilities:

There are two types of terminals used by Class I railroad companies:

- Intermodal terminals: located at the beginning or end of a rail corridor. Intermodal terminals are used for the storage of and transfer of containers. Usually trucks are used to transport of containers between the intermodal facility and the beginning or end of the journey.
- Classification yards: where sorting of cars onto different tracks is carried out. There are two types of classification yards: flat yards (cars organized by switching locomotives) and hump yards (trains are pushed up a hill used to sort the cars) (Bryan, Weisbrod, & Martland, 2007).

2.4.2 Type of Service Provided

There are three primary types of rail services. Each service has different issues with time traveling and delays:

- Carload service: Transports boxcars, gondolas, tank cars, and others (Brogan et al., 2013). Shipments travel in trains of mixed commodities and different origins and destinations. This type of service is the least reliable of the three because trains can stop at one or more classification yards during the trip and every classification increases the chance the car will miss a connection or arrive late to its final destination. The percentage of trips arriving within a 24 hour window is 32%. (AASHTO, 2018).
- Bulk unit trains: move coal from mines to power plants; or grains from farms to ports. These are the lower-end price of service provided (Brogan et al., 2013). The customer buys the entire train and the train travels from one point to one destination: trains usually bypass intermediate classification yards making the service more reliable than the ‘carload service’. The percentage of trips arriving within a 24 hour window is 42%. (AASHTO, 2018).

- Premium rail and intermodal service: refers to the transport of international and domestic containers and trailers (Brogan et al., 2013). Intermodal transport in terms of traveling time is the fastest type of transport because of the requirements of intermodal shippers. Customers are concerned with the timely arrival of containers, with being able to track their shipments and anticipate late arrivals. The percentage of trips arriving within a 24 hour window is 89% (AASHTO, 2018). This type of service is exclusively offered by Class I Railroads (AASHTO, 2018). Intermodal transportation is the fastest growing segment within rail freight. Export and imports account for about half of the intermodal traffic from Class I Railroads (AAR, 2018b).

2.4.3 Type of Commodities Transported:

Rail provides low-cost transportation for long-distance shipments and bulk goods. Some of the products most commonly transported by rail include coal, agricultural and petroleum products. The percentage the larger groups of commodities transported by rail during 2017 is shown in Figure 2.2. Coal was the largest single source of rail revenue; however, intermodal transportation which transported different commodities such as food, clothing and electronic devices increased their percentage share of the total transportation. During 2018, intermodal accounted for 24% of the revenue for major U.S. railroads (AAR, 2018b).

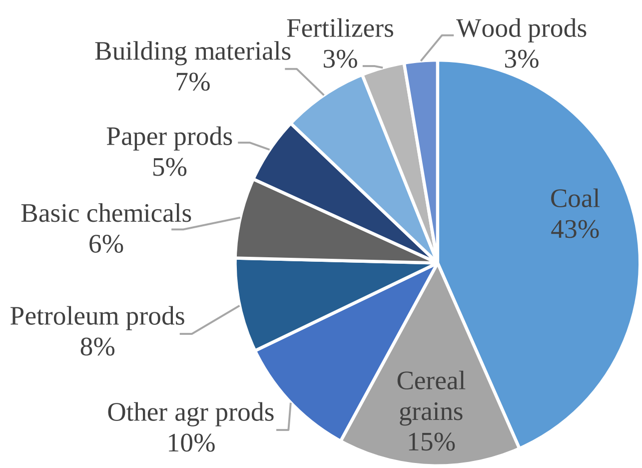

Figure 2.1: U.S. Commodities Transported by Tail (total ton-miles)
Adapted from: (U.S. DOT, 2019)
*Data from 2017, includes total flows: domestic, imports and exports

2.4.4 Pricing

Railroad companies use differential pricing to charge their customers (AAR, 2018a). Prices vary based on customers' location and other transport opportunities they may have. Customers that have fewer options to transport are charged higher prices than those with more competitive transport options. This is done because railroad companies have high fixed costs which need to be maintained. Fixed costs refer to tracks, locomotives, cars and railyards which as previously stated are maintained by the companies themselves (AAR, 2018a).

Railroads mostly serve customers transporting large shipments (more than 5,000 shipments per year) (AASHTO, 2018). For CN and CP for example, large shipments account for 82% and 76% of the annual railway traffic respectively, while small shipment customers less than 300 shipments per year account for 2% and 4% of the total traffic respectively. Smaller shippers do not benefit from volume pricing and might even get higher fees (AASHTO, 2018).

2.5 Air Emissions Caused by Rail Freight

Class I line haul locomotives are the largest source of rail-related emissions in the U.S. The estimates of fuel consumption for Class I railroads line-haul is approximately 74 to 84 percent of all rail sources combined; and 93% of the emissions of line haul and switcher combined (Bergin et al., 2012).

Locomotives used by Class I railroads in the US are usually diesel-electric or electric, with the majority being diesel-electric (Gould & Niemeier, 2009). Class I rail locomotives in the US emit GHG (CO_2, CH_4, N_2O) and air pollutant gases (CO, NO, HC and $PM_{2.5\ \&\ 10}$) (O'Rourke et al., 2012). The major problem is the emissions of CO_2, a GHG. Greenhouse gases affect climate change by increasing temperature in the atmosphere, and scientists claim there is a need to reduce GHG emissions to avoid an increase of the temperature and climatic changes such as a reduction of rain and melting of snow and ice (IPCC, 2014). However, air pollutant emissions also have negative effects, since they affect the health of populations living both along tracks and in close proximity to railyards (Bergin et al., 2012).

Locomotives' gasses emitted and concentration depend on several factors such as the type of fuel, locomotive's age, engine model, horse-power capacity and the proportion of time spent on each throttle notch (Gould & Niemeier, 2009). Hence, type and quantity of gases emitted vary between locomotives. In a study from the Port of Long Beach Authority from 2008, an example of the quantities and types of gases emitted by Class I locomotives around the country was offered. In the report, the exact quantities of gas emissions from line-haul and switcher operations in and around the port were identified. Line haul locomotives were primarily General Electric, which used a combination electric-diesel energy for operation. Diesel was their primary energy source. Switcher locomotives, were mostly EMD (Electro-Motive Diesel) engines, which were also diesel and electric locomotives (Starcrest Consulting Group, 2008). Air emissions measured included criteria air pollutants and GHGs. The proportion of each gas from the combination of switching and line haul use is represented in Figure 2.4. Emissions of CO_2 (a GHG) represent the highest proportion of emissions at 98 percent.

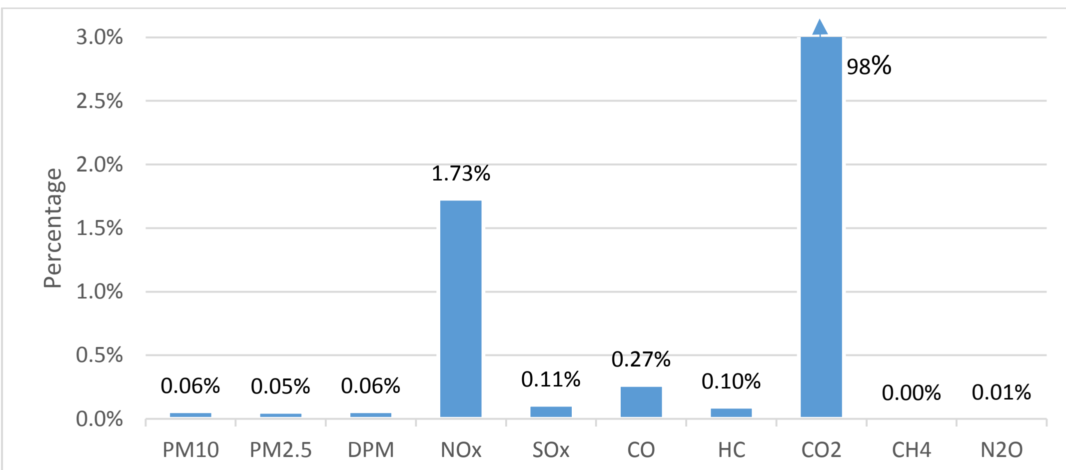

Figure 2.2: Port of Long Beach Estimated Emissions from Locomotives
Source: (Starcrest Consulting Group, 2008)

2.5.1 Greenhouse Gases

Greenhouse gas emissions caused from Class I Rail freight transportation depend more on the type of fuel used than on the engine of the locomotive. The primary GHG associated with the combustion of diesel engines is Carbon Dioxide (CO_2) (98 percent of the pollutants generated by locomotives). Other GHGs produced although in much lower proportions are methane (CH_4), and nitrous oxide (N_2O) and Hydrofluorocarbons (produced from air conditioners used to cool freight and people) (O'Rourke et al., 2012).

Greenhouse gases are present in the atmosphere both naturally and due to human activity. GHGs are: water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the human created GHGs; sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF3) (U.S. EPA, 2018b). Greenhouse gases cause the greenhouse gas effect, they absorb and emit thermal infrared radiation (heat) emitted by the Earth's surface, by the atmosphere itself, and by clouds (March, Planton, & Von Stechow, 2014). A rise of GHGs in the atmosphere leads to an increased greenhouse effect (gases trapping and releasing heat) and thus, an increase of the earth's temperature. Each gas has a different effect on global warming which depends on their concentration, the amount of time they stay in the atmosphere, and their heat-absorbing capacity.

Water vapor has the highest concentration in the atmosphere and its contribution to the natural greenhouse effect is similar to CO_2. Yet, water vapor is not considered a threat to environment because it remains in the atmosphere on average ten days and its impact does not contribute significantly to the GHG effect (March et al., 2014). GHGs that are detrimental for the environment are CO_2, CH_4, and N_2O. They can stay years in the atmosphere causing a warming effect (IPCC, 2014a). CO_2 for example stays in the atmosphere between 90-95 years and the human created gases can stay between 500 to 50,000 years. CO_2 represents the highest proportion of gases that have increased their concentration in the atmosphere due to human activity (See Fig. 5.3).

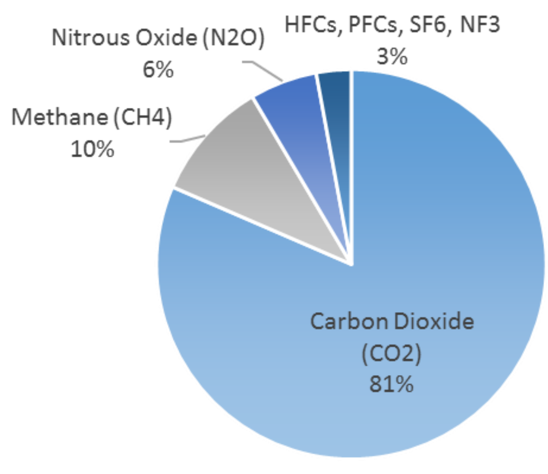

Figure 2.3 U.S. GHG Emissions by Gas
Source: U.S. (U.S. EPA, 2018a)

2.5.2 Criteria Air Pollutants

Rail freight emissions of criteria air pollutants are considered to be more dependent to the engine's characteristics rather than on the type of fuel consumed. Emissions of these gases are much lower than CO_2, yet, the EPA has established standards for these gases based on long and short term human effects (O'Rourke et al., 2012). There are six criteria air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2) and lead (Pb). Volatile organic compounds (VOCs) also referred as hydrocarbons, are not a criteria air pollutant, they are considered along with them since they are precursors of ground-level ozone (O'Rourke et al., 2012).

Environmental consequences of particular importance come from carbon monoxide (CO) and nitrogen oxides (NO_x and NO_2) which are considered indirect GHGs gases. Although indirect GHGs do not have the same global warming effect as GHGs, they do contribute to the planet's temperature increase (U.S. EPA, 2018a). Carbon monoxide and nitrogen oxides are precursors of tropospheric O_3 and aerosol concentration (precursors are atmospheric compounds that are not greenhouse gases, but take part in physical or chemical processes that regulate the production or destruction of GHGs). Ozone is located on both, the stratosphere and on the troposphere (all other GHGs and criteria air pollutants are located on the troposphere). Most of the O_3 is located on the stratosphere and is not considered a threat to the environment. Stratosphere O_3 absorbs harmful ultraviolet radiation from the sun preventing it to reach the earth's surface (U.S. EPA, 2018b). However, tropospheric (or ground level) ozone acts as a greenhouse gas, as it can absorb infrared radiation (Stocker et al., 2013). Tropospheric ozone is a considered harmful pollutant, it can cause several respiratory problems in humans and damage forests and crops (U.S. EPA, 2007).

Another detrimental effect of CO, is that when in interaction with other compounds such as hydroxyl (the major atmospheric sink for CH_4 emissions), forms CO_2. This means that a high concentration of CO will limit the number of hydroxyl molecules (OH) available to destroy CH_4 (U.S. EPA, 2018a).

2.6 <u>Legislation for Emissions Reduction in Rail</u>

The U.S. EPA, though the Clean Air Act has the authority to set standards for six pollutants that are considered harmful to human health and the environment (ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, lead and particulate matter) (U.S. EPA, 2007). EPA's locomotive standards regulate four of those Criteria Air Pollutants and apply to all rail locomotives operating in the country. The Canadian Government has also set standards to Class I Railroads operating in their territory, which align with the US Standards. In addition, the Canadian Government also encourages companies to reduce GHG emissions by signing agreements with companies. Finally, the state of California's Transportation Authority (CALTRANS) works towards reducing the emissions caused by rail freight within the state by signing special agreements and encouraging federal legislation to reduce the current emission limits.

2.6.1 EPA's Locomotive Standards

The EPA standards apply to railway locomotives operating in the two modalities (line-haul and switching) that have engines fueled by diesel and/or by other fuels. Regulated air emissions are: Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx) and Particulate Matter ($PM_{2.5\ \&\ 10}$). Emissions limits for each gas varies depending on the year locomotives were manufactured or remanufactured (locomotives in the U.S. are mostly designed to be remanufactured during their lifetime once every seven to ten years). Standards are divided in five groups: Tier 0-2 standards, adopted in 1997 and effective since 2000; and tier 3-4 standards adopted in 2011/2012 and effective since 2015 (See Appendix 1). Standards do not apply to locomotives manufactured or remanufactured before 1973. The standards were designed so that emissions reductions are achieved in any operating condition from high power cycles to the lower ones (Gould & Niemeier, 2009).

In addition to the standards' compliance, the EPA requires all newly manufactured and remanufactured locomotives to incorporate devises to shut down the locomotive if idling unnecessarily (U.S. EPA, 2013). Also, since December 30, 2009, EPA requires reporting of GHG emissions from all sectors of the economy.

2.6.2 Canadian Standards & Memorandums

The approach for setting standards for the Canadian Government is to align them with the US EPA's federal standards (DieselNet, 2020). Locomotive emission standards were emitted by Transport Canada in 2016, they apply for the same gases as the US EPA standards, include the same emission limits and are effective the same dates as the American Standards (DieselNet, 2020). In addition to ensuring railroads comply with Standards that legislate Criteria Air Pollutants, “Transport Canada” has since 1995, signed memorandums with the “Railway Association of Canada” for reducing locomotive GHG emissions (Transport Canada, 2013). The Canadian Government committed to reducing GHG emissions by 17% below 2005 levels by 2020. The emission reduction target set in the 2011 Memorandum is a reduction of 6 percent from 2010 by 2015, companies are encouraged to “make every effort to reduce the GHG emissions intensity from operations” (Transport Canada, 2013).

Memorandums applicable to the period of study are the 2006-2010, 2010-2015 which covered operations until 2017, and the Memorandum 2018-2022. According to the 2019 report for the 2010-2017 Memorandum, Class I Railroad Companies achieved a 16.99 percent decrease of their GHG emissions in the period between 2010 and 2017. GHG emission initiatives supported by the government and the industry were: Fuel efficiency technologies, locomotive fleet renewal and energy efficiency improvements, enhancing engineer simulation training programs and the development of new technologies related to lighter construction materials for railcars and distillation of renewable diesel fuel (Delphi & Delphi, 2019).

- Environment Canada finalized Renewable Fuel Regulations in Canada which introduced requirement for annual average of 2% renewable content in produced and imported diesel (enforced from July 1, 2011) (Canadian Pacific, 2012).

2.7 Summary

This chapter included information related to Class I Railroads operating in the U.S. Rail was the most important transport mode when it was the fastest mode available. Nowadays, rail is used to transport low-value items for long distances such as coal and agricultural products. Though, in the past few years transport of coal has reduced while intermodal transport which includes different commodities such as food and electronics has grown. Rail companies mostly operate diesel locomotives which emit GHG and Criteria Air Pollutants. Legislation to control emissions (Tier 0-4 emission standards) is focused on reducing criteria air pollutants emissions. Canadian legislation however, through its Memorandums of Understanding is targeting the reduction of GHGs.

CHAPTER 3. LITERATURE REVIEW

3.1 Introduction

In this chapter, the concepts behind CSR and sustainability reporting were explored. Second, specific standards the rail freight industry have used and the philosophy behind each of them were mentioned. Third, aspects that can be implemented by the rail industry to reduce their air emissions and increase capacity were mentioned. Fourth, factors that influence the implementation of those aspects were considered. Finally, methods commonly used in the research of companies' CSR reports were analyzed.

3.2 Theoretical Foundation

There were several theories identified and used by researchers in the analysis of Corporate Social Responsibility (CSR) or sustainability reports. Sustainability and CSR are the key concepts companies use for voluntarily reporting, as aspects companies report on include economic, social and environmental concerns related to their operations. Although having slightly different origins, in recent years, the concepts of sustainability and CSR have been considered similar and there is been mention of an uncertainty on the difference between them (Piecyk & Björklund, 2015b). Other theories which originated from CSR and are also used when explaining sustainability and CSR reporting are stakeholder and legitimacy theory. The following section includes an analysis of the different theories: sustainability, CSR, legitimacy and stakeholder theory applicable to freight transportation.

3.2.1 Sustainability Concept

There are many definitions of sustainability or sustainable development. Since the mid-1980s, the term sustainable has been part of the academic vocabulary and it is interpreted in a number of ways (Portney, 2015). The main reference most authors use as a starting point is the United Nations', as economic-development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The book also referred as the Brundtland Commission

Report, explained sustainability has three equal parts or elements: environment, economy and equity (World Commission on Environment and Development, 1987). According to the report, economic sustainable development should occur as long as the environment can support such growth considering all societies achieve the same level of growth. As it stands, there are inequalities in the world, so sustainable development will ensure all societies can meet essential needs without compromising the natural environment (World Commission on Environment and Development, 1987).

From the many definitions about sustainability, there is consensus amongst people about its abstract ideas. However, when put into practice, there is less agreement on the role each element plays and the trade-offs people or organizations are willing to give to achieve sustainability and desired outcomes (Jacques, 2014).

3.2.2 Corporate Social Responsibility Concept

The concept of corporate social responsibility, is considered to have emerged during the 1950s (Camilleri, 2017). However, social practices from private companies' originated during the industrial revolution (Carroll, 2009). Some of the social responsibility ideas that appeared during the 1800s were concerned with the social welfare of employees, for example, several companies donated to charities and community projects such as schools and community groups (YMCA and YWCA) (Carroll, 2009). Social awareness and the overall recognition of the social responsibility of businesses in community affairs shifted during the 1950s (Carroll, 2009). During the 1950s and 1960s concerns were voiced by the academia about companies' responsibilities toward their employees, customers and the public in general (Camilleri, 2017). Some of the concerns that emerged were related to the management of companies, and whether companies should only pursue the interest of their shareholders or the interest of the wider community (Camilleri, 2017). In addition, during the 1960s social and environmental movements, such as the civil rights movement and the environmental movement concerned with air pollution, grew in the U.S. These movements heavily influenced corporate behavior in the U.S. as campaigns demanded corporations to treat employees with respect and fairness (Haerens & Zoot, 2014), and the implementation of the Clean Air Act from 1963.

Howard Bowen, is considered as one of the first persons to write about the CSR concept after the 1950s (Carroll, 2009). Bowen saw CSR as the responsibility companies have toward societies. Although, there is not an agreement on what aspects companies should direct their efforts toward and how they should be judged, Bowen considered that a way to judge them is by considering societies' fundamental values in which they set their economic, political and social orders (Bowen, 2013). Bowen argued that if societies' ideas about its responsibility toward the environment evolve and change, then so will the ideas of a corporation. Because managers of large corporations are immersed and influenced by societies, consequently, corporations' performance will be directed to satisfying manager' beliefs whether it being environmental, social or other (Bowen, 2013). Bowen saw business obligations toward societies (workers, consumers, general public) as a condition for their survival (Bowen, 2013).

The concept of CSR evolved and slightly shifted through the following decades since its initial conceptions in the 1950 and 1960s. During the 1970s, ideology of what was considered the obligations of businesses changed to some extent. Instead of being accountable to guarantee their own survival, business' social responsiveness focus changed to emphasizing what the companies could do better (May, Cheney, & Roper, 2007). Milton Friedman's ideas are mentioned by several authors as being influencing at the time (See May et al., 2007). Friedman was critical about expanding enterprises responsibilities and advocated that an enterprise responsibility was only to its shareholders (May et al., 2007).

During the 1980s authors expanded CSR discussion to include stakeholders' influence in companies. Stakeholders can be employees, customers, suppliers, communities and others. The 1980s was also a time when heavy deregulation of previously state-owned enterprises occurred in capitalist countries and ideas of 'free market' were wide-spread (May et al., 2007). During the following decade, the 1990s discussion of CSR intensified. CSR was seen as a firm's internal and external communication, and its policies and commitments to CSR. Reporting schemes such as GRI started to emerge in the late 1990s and early 2000 and businesses have been developing stand-alone reports since then (Lambrechts et al., 2019).

The concept is CSR has evolved and shifted its focus though the years, yet, it has always been linked to ethical aspects of business. Although, there is still not a consensus of what the CSR concept entitles, the CSR concept started and has mostly been related to social aspects which includes impacts of a specific to the different stakeholders (employees, communities). Currently, some researchers use the CSR term as a synonym of sustainable development. Piecyk & Bjoklund

(2015b) see CSR as a way businesses address sustainability concepts: economic, environmental and social performance.

3.2.2.1 Stakeholder and Legitimacy Theory

Stakeholder and legitimacy theory were considered the most used theories to investigate and understand CSR and sustainability disclosure (Lambrechts et al., 2019; Vourvachis & Woodward, 2015). Under stakeholder theory, organizations are mentioned to have obligations and responsibilities with many ‘stakeholders’ (Lambrechts et al., 2019). When first proposed in the 1980s, the theory was used to raise awareness among companies to act in a responsible way toward different stakeholders (Camilleri, 2017). Under stakeholder theory, business management goes beyond only looking after the interests of a companies’ shareholders. Management adopts an inclusive attitude by considering the interest of all stakeholders including employees, investors, customers, suppliers and the wider community […] (Law, 2018). It has been recognized however that the interest of stakeholders may be different and a company does have an obligation towards its shareholders. As a result, theorizers suggested including stakeholders in decision processes. This could benefit all stakeholders and even increase value for shareholders (Camilleri, 2017). In addition to generating value for companies’ shareholders, it has been argued that a company should minimize the negative impact of primary stakeholders (customers and suppliers), and of other stakeholders less affected by the company (i.e.: wider community and environmentalists) (Camilleri, 2017). In this sense CSR reporting is seen as a way companies communicate in response to the requirements of different stakeholders.

Legitimacy theory instead operates under the notion that companies function in society provided that they agree to preform various socially desired actions in return for approval of their objectives (Guthrie & Parker, 1989). Given community awareness, companies take measures to ensure their activities are acceptable (Al Farooque & Ahulu, 2017). Under legitimacy theory, corporate disclosure is seen as a reaction to environmental factors that can include: economic, social and political factors of the time (Guthrie & Parker, 1989). Overall, CSR reporting under legitimacy and stakeholder theory is seen as a tool to gain societal acceptance by maximizing benefit for different stakeholders and by minimizing negative social and economic factors. Obtaining legitimacy is considered important since companies want to keep a positive reputation in societies (Masud, Bae, & Kim, 2017).

3.2.3 Sustainability and CSR Concept in the Freight Transport Industry

There is no exact definition of sustainable freight transport. Yet, research related to sustainable freight transportation is targeting the reduction of carbon emissions caused by transport and reducing its health and safety impacts (See Mckinnon, 2015; Tavasszy & Piecyk, 2018). An early specific definition of sustainable transport is given by the Organization for Economic Co-operation and Development (OECD), which in 2001 defined sustainable transport as transport that:

> *"does not endanger public health or ecosystems and meets needs for access consistent with a) use of renewable resources below their rates of regeneration, and b) use of non-renewable sources below the rates of development of renewable substitutes."* (OECD (Organization for economic Co-operation and Development), 2002).

EU's transport ministers agreed on the previous definition and in 2001, gave a more specific definition considering transport as a system that should:

> *"Allow basic access and development needs of individuals, companies and societies to be met safely, in manner consistent with human and ecosystem health, and promote equity within and between successive generations;*
>
> *Limit emissions and waste within the planet's ability to absorb them, use renewable resources at or below their rates of generation, and use non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise"* (European Comission, 2001)

Based on the previous definitions, the UK government developed a concept of 'sustainable development for the distribution industry'. The aim of sustainable distribution concept is to ensure economic growth without compromising the future need of societies and the environment (Piecyk & Björklund, 2015a). The concept includes specific outcomes to be achieved in each of the three aspects of sustainability: environment, economy and society. Some aspects included as part of the environmental outcomes are: Contribute to GHG reduction target, meet EU and UK air quality standards, minimize was and impact of waste produced (Piecyk & Björklund, 2015a).

A different definition for sustainable freight transportation was developed by the European FREIGHTVISION project. The project, whose task in 2015 was to find actions and research to address improving the freight system in Europe, provided an insight of critical aspects that need to be addressed to achieve a sustainable freight transport (Helmreich & Keller, 2011). FREIGHTVISION, considers sustainable freight transportation is little concerned with sustainability outcomes such as food security and health care. However, there are four elements the project considers critical to address: reducing GHG emissions and fossil fuel share; and reducing road fatalities and traffic congestion (Helmreich & Keller, 2011). Although there is a difference in the definitions of 'sustainable freight' proposed by the two European organizations, reducing GHG emission and improving air quality are the most important elements that both organizations mention need to be addressed. Additionally however, reducing road fatalities is also an important aspect that needs to be addressed.

3.2.4 Summary Sustainability and CSR Concepts

Both sustainability and CSR concepts reflect the ideas and worries of the societies from different times to address environmental and social issues that large enterprises may be affecting. Both theories have been complementary to each other. Sustainability ideas started with an environmental focus while CSR debate began with a concern for social aspects. Through the years, sustainability has included social aspects and CSR has incorporated environmental issues in their philosophies. Legitimacy and stakeholder theories are used to explain reasons why companies desire to report and communicate their achievements and projects. CSR reporting is seen as a way for companies to communicate with different stakeholders, look for their approval and to improve their competitive advantage. It has been suggested that a company's success should not only be measured by its economic success, but by its social and environmental performance (Piecyk & Björklund, 2015b).

3.3 CSR Reports Used in the Logistics Industry

Corporate Social Responsibility (CSR) and Sustainability reporting refers to the evaluation of financial and non-financial performance of companies (White, 2016). Reports' objective is to make public and transparent information related to companies' or organizations corporate social responsibility actions and results. CSR reporting is voluntary and companies report annually to different guidelines to measure their economic, social and environmental impacts. CSR and sustainability reports are also seen as documents that assist companies in the change to achieve sustainable or corporate responsible development (White, 2016).

Many academics are doubtful that reporting can influence or change behaviors of companies or that corporations are capable of having true responsibility of their actions (Christensen, 2007). However, others did point to the importance of CSR reporting and allowing companies to communicate their ideals, as those ideals could actually help shape management practices and influence companies become more socially or environmentally conscious. Allowing companies to report on matters they consider material could help give light in aspects that can be improved which can improve our expectations and demands from corporations (Christensen, 2007).

Most Class I railroad companies have reported voluntarily to the Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP) and to the Sustainability Accounting Standards (SASB) during the past 10 years. GRI sustainability guidelines are the most widely acceptable reporting guidelines (Al Farooque & Ahulu, 2017) because they are used for reporting on all aspects of sustainability; economic, social and environmental aspects. The CDP guidelines are also widely used, but their focus is on environmental issues: climate change (CO_2 emissions), water management and forests conservation (CDP, 2018a). Finally, the SASB, developed standards specific for different types of industry including rail, to be used voluntarily when filing US regulation forms from the Securities and Exchange Commission (Forms 10-K and 20F) (SASB, 2017). SASB standards also cover information related to companies' sustainability aspects. In the following sections an overview of the three guidelines (GRI, CDP and SASB) is given.

3.3.1 Global Reporting Initiative

GRI is an independent international organization established in 1997 in the U.S. GRI's headquarters are located in The Netherlands, with representatives in each continent. GRI develops standards that are used by organizations to understand and communicate their impacts and contributions (positive or negative) on sustainability issues related to economic, environmental and social aspects (GRI, 2016b). GRI guidelines are the most used standards by companies when reporting. From the world's largest corporations, 93% reported on their sustainability performance using the GRI scheme in 2016 (GRI, 2016a) .

The reporting scheme of the GRI is adaptable. Organizations can use the guidelines and report on as many or as few components they desire based on company's specific impact areas related to their economic, social and environmental impacts. Concepts organizations need to consider to determine which aspects to report on are:

- Stakeholder inclusiveness: The report is expected to include reasonable interests and expectations of stakeholders. Stakeholders are all people that are significantly affected by the organization's products, activities or services.
- Sustainability context: The report needs to include information based on broader concept of sustainability. By explaining how the company contributed or aimed to the improvement or deterioration of economic, environmental and social conditions. Also, sustainability aspects need to be explained within a context based on the limits and demands at the sectoral, local, regional or global level.
- Materiality: companies need to report on material topics. The GRI referred to material topics as those that reflect the companies' social economic or environmental impacts. Also material topics were areas of interest that could significantly influence the assessments and decisions of stakeholders (GRI, 2016b).

Although reporting organizations select key themes and which indicators to report on based on the concepts previously mentioned, the GRI also developed a few sector-specific guidelines. Sector specific guidelines applicable to rail freight transportation is the 'GRI Logistics and Transportation Sector Supplement" (LTSS) from 2006. The LTSS consist of a list of additional indicators, again based on their economic, social and environmental impacts that are added to the list of indicators from where companies choose to report on. Environmental performance indicators companies are encouraged to report on are energy consumption, pollution, and fleet composition amongst others. Indicators from the LTSS are summarized in Table 3.1.

Table 3.1: GRI Logistics and Transportation Sector Supplement Summary Table

Aspect	Indicator
Fleet compositions	Breakdown of fleet composition
Policy	Description of policies and programs on the management of environmental impacts. 1) Initiatives on sustainable transportation (hybrid vehicles); 2) Modal shift; and 3) Route planning.
Energy	Description of initiatives to use renewable energy sources and to increase energy efficiency.
Urban Air Pollution	Description of initiatives to control urban air emissions in relation to road transport (e.g., use of alternative fuels, frequency of vehicle maintenance, driving styles, etc.).
Congestion	Description of policies and programs implemented to manage the impacts of traffic congestion (e.g., promoting off-peak distribution, new inner city transport modes, percentage delivery by modes of alternative transportation)
Transportation Infrastructure Development	Description of environmental impacts of the reporting organization's major transportation infrastructure assets (e.g., railways) and real estate. Report the results of environmental impact assessments.

Source: (GRI, 2006)

3.3.2 Carbon Disclosure Project

Created in 2000, the CDP is an international non-profit organization based in the United Kingdom. The CDP has subsidiaries in 50 countries and supports companies, cities, or states and regions on disclosing environmental information (CDP, 2018a). Unlike the GRI that addressed sustainability aspects, the CDP is solely focused on preventing climate change and environmental damage. Therefore, the CDP only collects information related to organizational environmental impacts. The CDP developed questionnaires that address three specific areas: climate change, water security and deforestation. Organizations select a questionnaire to report on based on their major impacts and the CDP uses the information provided by organizations in their reports to prepare annual company reports that can be used by possible investors, or any stakeholder (CDP, 2018a). Over 3,600 large companies disclosed their environmental data to the CDP in 2017 (CDP, 2018a).

Most Class I Railroads reported to the CDP Climate Change questionnaire during the past 10 years. The climate change questionnaire included questions related to CO_2 emissions, quantity and strategies to reduce emissions. Since the CDP's climate change questionnaire only addressed CO_2 emissions, questions included a wider variety of aspects than the GRI, such as: investment on low-carbon technologies and participation in public policy development (CDP, 2018b). Similar to the GRI, the CDP also had sector specific questions for "Freight transportation" which were added to the main questionnaires. Table 3.2 has a summary of areas of interest addressed in the climate change questionnaire for Transport Services companies.

Table 3.2: Summary CDP Climate Change Questionnaire

Area of interest	**Specific questions**
Governance	Oversight of climate-related issues within organization: board level, bellow board-level responsibility, managers and employee incentives.
Risks and opportunities	Climate related risks and opportunities, management processes, processes for identifying, assessing and managing climate-related issues.
	Resource efficiency (use of more efficient transport modes and energy source (use of lower-emission sources of energy)
Business strategy	Indicate if the company has developed a low-carbon emission plan
Targets	Emission targets, emissions reduction initiatives, low carbon products (details of products considered low-carbon)
Energy	Energy spend, fuel consumption, energy consumption totals, transport-related energy efficiency metrics.
Additional climate-related metrics	Low carbon technology implementation, low carbon investments, investment in research and development of equipment, products and services for a low-carbon transition.
Carbon pricing	Operation activities regulated by a carbon pricing system, organization's engagement in activities that could influence public policy on climate-related issues.

Source: (CDP, 2018b)

3.3.3 Sustainability Accounting Standards

The SASB is an independent non-profit standards board founded in 2011 in California, US, its mission is to develop sustainability accounting standards to help corporations disclose decision-useful material information to investors (SASB, 2017). Sustainability was interpreted by SASB as ‘corporate activities that maintain or enhance the ability of the company to create value over the long term’ (SASB, 2017). SASB considered value creation was not only related to financial statements, but to aspects such as human capital and corporate governance. Therefore, sustainability dimensions included more aspects than the three commonly considered. SASB organized sustainability topics under five dimensions: environment, social capital, human capital, business model innovation; and leadership and governance (SASB, 2017).

Similar to the CDP, SASB developed specific guidelines for companies to use when disclosing information based on the materiality concept. However, in this case, standards are industry specific. Material topics for each industry were determined by SASB based on the concept of materiality as defined by the U.S. Supreme Court as topics that have “a substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the “total mix of information made available” (SASB, 2016). SASB classified industries into 11 types, rail freight transportation belongs to the transportation sector and land transportation sub-sector (SASB, 2018). Material topics for the rail freight industry include: 1) environment, referring to GHG and other pollutant emissions; 2) human capital, which addresses employee safety, and; 3) leadership and governance which refers to safety management (SASB, 2018). A summary of disclosure topics and the specific questions to each topic is presented in Table 3.3.

3.3.4 Summary

The three reporting schemes reflect different approaches to developing a reporting standard. Only SASB has standards applicable to the rail freight industry. However, GRI’s and CDP’s schemes are to be used and adapted by rail freight service providers. The GRI developed guidelines for the “Transportation Sector” reporting and the CDP adds questions to their main “Climate Change” questionnaire based on the industry type (Transport services). GRI and SASB identified in their frameworks aspects companies should be reporting on based on the concepts of sustainability, materiality and stakeholder involvement (the latter considered by GRI as a separate concept, and; by SASB as part of its materiality definition). Although SASB’s guidelines were more specific for rail and the GRI’s open for interpretation, both guidelines considered energy consumption, emissions and strategies to reduce emissions as important aspects to be reported by rail freight transportation service providers.

Table 3.3: Summary SASB Rail Transportation Standard

Area of Interest	Specific Questions
Environment	
Greenhouse Gas Emissions	1) Gross global Scope 1 emissions 2) Discussion of long-term and short-term strategy or plan to manage Scope 1 emissions, emissions reduction targets, and an analysis of performance against those targets 3) Total fuel consumed, percentage renewable
Air Quality	Air emissions of the following pollutants NOx (excluding N2O) and particulate matter (PM10)
Human Capital	
Employee Health and Safety	1) Total recordable incident rate 2) Fatality rate, and 3) Near miss frequency rate
Leadership and Governance	
Competitive Behavior	Total amount of monetary losses as a result of legal proceedings associated with anticompetitive behavior regulations.
Accident and Safety Management	1) Number of accidents and incidents 2) Number of accident releases and non-accident releases 3) Number of Federal Railroad Administration Recommended Violation Defects 4) Frequency of internal railway integrity inspections

Source: (CDP, 2018b)

3.4 CSR and Sustainability in the Logistics Industry

Research of environmental effects caused by freight transportation mostly started to appear in the literature in the 1960s (Mckinnon, 2015). Interest in the subject grew as a result of a public policy agenda driven by pressure groups, which later, included the interest from the private industry sector. Initial research in environmental effects of freight transportation carried out during the 1960s and 1970s focused on freight's local impact in cities such as air pollution, noise, traffic congestion, vibration and road fatalities (Mckinnon, 2015). This is also the time when the "Clean Air Act" was developed in the U.S. The Act included limits for criteria air pollutants from rail and other transport modes. During the 1980s, research determined that transportation could have effects on the global atmosphere and consequently, the scope research related to freight's environmental effects shifted to dealing with GHG emissions (Mckinnon, 2015). Concern over the effects of Green House Gas (GHG) emissions on the planet caused by the transportation sector has grown. This is shown in the increase in the number of studies analyzing ways to reduce air emissions caused by freight transportation in the past ten to fifteen years (Marchet et al., 2014).

There was significant research found where academics analyze the CSR reporting of logistics service providers. There are different aspects researchers aim to identify such as common indicators companies are reporting on, aspects that might be influencing companies' reporting, and more theoretical research related to the quality of the reporting on it being on material aspects or on more symbolic aspects. Research on LSPs reporting has been carried out based on existing standards such as the GRI (Lambrechts et al., 2019; Piecyk & Björklund, 2015a), the CDP (Herold & Lee, 2017b) or on aspects identified by the researcher(s) as important actions to become sustainable or to become environmentally sustainable based on a review of the literature (Ciliberti, Pontrandolfo, & Scozzi, 2008; Evangelista, 2014; Evangelista, Santoro, & Thomas, 2018; Marchet et al., 2014).

Findings from studies that analyze the reporting of LSP have determined that CSR reporting of the logistics industry has not yet reached uniformity, required to identify which aspects are considered material (Piecyk & Björklund, 2015b). To understand the reporting of the logistics industry, scholars have mentioned that research can be carried out by narrowing the scope and research in different areas such as being sector-specific (focus on air cargo, road haulage or warehousing), being of a specific transport mode or being specific to a country (Lambrechts et al., 2019; Piecyk & Björklund, 2015b).

3.4.1 Analysis of CSR Reports from Class I Railroads

Rail is one of the least polluting modes available for freight transportation, yet, the industry has still been considered one of the primary consumers of fuel and energy in the U.S. (Saadat et al., 2016). Most Class I rail locomotives in the U.S. operate with diesel engines, which emit GHG (CO_2, CH_4, N_2O) and air pollutant gases (CO, NO, HC and $PM_{2.5\ \&\ 10}$). The major problem is the emissions of CO_2, a GHG which causes global warming (Lambrechts et al., 2019). However, air pollutant emissions also have a negative effect by affecting the health of populations living both along tracks and in close proximity to railyards (Bergin et al., 2012).

Class I railroad companies have been voluntarily reporting to different schemes for the past 10 years. However, there is no literature that has studied only from rail service providers. On one hand, research related to reducing emissions from the rail freight sector has been carried out in isolation, i.e.: intermodal transport and its benefits in terms of emissions (Bickford et al., 2014; Pinto, Mistage, Bilotta, & Helmers, 2017), improvement of locomotives technologies (Brecher & Shurland, 2015; Gunselmann, 2005; Saadat et al., 2016) amongst others. On the other hand, analysis of CSR or sustainability reports from railroad companies have been part of studies analyzing reporting of third-party logistics service providers (Piecyk & Björklund, 2015b). Analyzing CSR or sustainability reports has allowed for a holistic view of how an industry is approaching sustainability or emissions reduction and the importance given by the industry to different aspects (technology improvements, intermodal connections). In this research, the analysis was carried out to Class I rail companies operating in North America. This allowed to identify common aspects on what companies considered important to become more sustainable, reduce air emissions and increase capacity.

The following sections address actions that can be implemented by Class I railroad companies to reduce air emissions caused during transportation. Followed by a review of CSR reports from third party logistics providers (3PLPs), which identify factors that may be influencing the implementation of those actions.

3.5 Actions to Reduce Air Emissions from Class I Railroad Companies

A number of aspects that Class I rail companies can implement to reduce their air emissions were identified, such as improvements to locomotives, and reducing idling times. Additionally, it was found that great importance given to the fact that rail is a low emissions transport mode. Increasing rail use, while reducing the use of other more polluting modes such as truck transportation, was seen as a way to help reduce air emissions from the entire freight transportation system (Bitzan & Keeler, 2011). The improvement of intermodal operations and operations within intermodal facilities were mentioned to help encourage and increase rail transport use (See Pinto et al., 2017). The literature did not mention one aspect as key to reducing energy consumption and therefore air emissions of rail freight. Instead, it was the combination of strategies that was considered as having led the industry to a reduction of energy consumption during the past 40 years (Frey & Kuo, 2007).

In Table 3.4, the different strategies found in the literature to reduce emissions from rail freight transport have been listed. The strategies include a sub-classification and a few authors that studied each topic.

Table 3.4: Classification of Strategies to Reduce Air Emissions from Class I Railroads

Sub-Theme	Authors
Operational Strategies	
External Operations	
Network cooperation w/other freight carriers / Operations in shared tracks	Mathers, Norsworthy & Wolfe (2014), Brecher, Sposanto & Kennedy (2014).
Collaboration with other private associations / with customers	Lammgaard (2012); Sniden (2019)
Internal Operations	
Railyard operations improvement (Lean management of railyards)	Dirinberger & Barkan (2007); Olesen, Power, Hvolby, H-H. & Fraser (2015); Pinto, Mistage, Bilotta & Helmers (2017); Otto & Pesh (2017)
Rail track operations improvement	Barkan (2007); Bryan, Weisbrod & Martland (2007); ASHTO (2018)
Information technology systems (Improvements to scheduling, tracking & dispatch, customer tracking information, fast pass)	Brecher et al. (2014); Bryan et al. (2007); Gunselmann (2005)
Efficient driving behavior	Gunselmann (2005); Brecher et al. (2014); Smokers, Tavasszy, Chen & Guis (2014)
Improvements to increase trains' energy efficiency	Brecher, et al. (2014); Gunselmann (2005)
Maintenance and lubrication improvements	Frey & Kuo (2007); Brecher et al. (2014)
Technological Strategies	
Locomotive Technology	Saadat, Esfahanian & Saket (2015); Brecher et al. (2014); Brecher & Shurland (2015)
Software tools for driving operations	Brecher et al. (2014); Brecher & Shurland (2015)
Alternative Fuels	Miller, Hess, Ericson & Dippo (2010); Dincer, Hogerwaard & Zamfirescu (2012); Brogan et al. (2013); Brecher et al. (2014); Shurland et al. (2014).
Car weight reduction initiatives	Gunselmann (2005); Frey & Kuo (2007); Brecher et al. (2014).
Infrastructure improvements	Bryan et al. (2007); Beherends (2012)

Findings of the search were classified into operational strategies and technological innovations. Classification was based on Colicchia et al (2013) and Smokers et al (2014), whose research analyzed aspects to reduce the environmental impact of logistics service providers. Colicchia et al. (2013), classified green-initiatives of logistics transportation services in technological innovations and management strategies. Technological innovations referred to aspects such as fleet technological innovation and use of alternative fuels. Management strategies included aspects such as: shifting traffic to more fuel efficient modes and sharing vehicles across multiple customers (Colicchia, Marchet, Melacini, & Perotti, 2013). Smokers et al., 2014 classified aspects that can be improved to reduce CO_2 emissions in logistics in technical, operational and logistical options. Technical options and operational options were similar to Colicchia et al. (2013) technological innovations and management strategies respectively. Logistical options included improvements such as network design, network cooperation and multimodal transport (Smokers, Tavasszy, Chen, & Guis, 2014). The difference between the classifications was that in Colicchia et al. (2013), intermodal transport improvements were part of the operational strategies while Smokers et al. (2014) separated intermodal transportation improvements as logistical options (a third category).

3.5.1 Operational Strategies

Operational strategies refer to aspects that can be improved to reduce air emissions from companies' transportation operations while maintaining existing fleets and infrastructure. Operational strategies spam from company's organization to improve intermodal transport and encourage modal shift, to specific operational changes such as improving trains fuel efficiency while driving. Operational strategies were sub-classified into external and internal operational strategies.

Although modal shift and intermodal transport were not directly related to reducing air emissions from Class I railroad companies, but to the entire freight system, they were included as part of operational strategies because of the importance given to them in the literature (See Bickford et al., 2014; Pinto et al., 2017). Rail was considered one of the least polluting freight transportation modes, increasing rail transport while reducing transport of other more polluting modes (truck and air transportation) was seen as crucial for reducing greenhouse gas emissions of the entire freight system and for reducing urban congestion (Peris & Goikoetxea, 2016). Rail is not as flexible as road transport, therefore it was promoted as part of a transportation system, where parts of a trip can be done using rail (multimodal transportation).

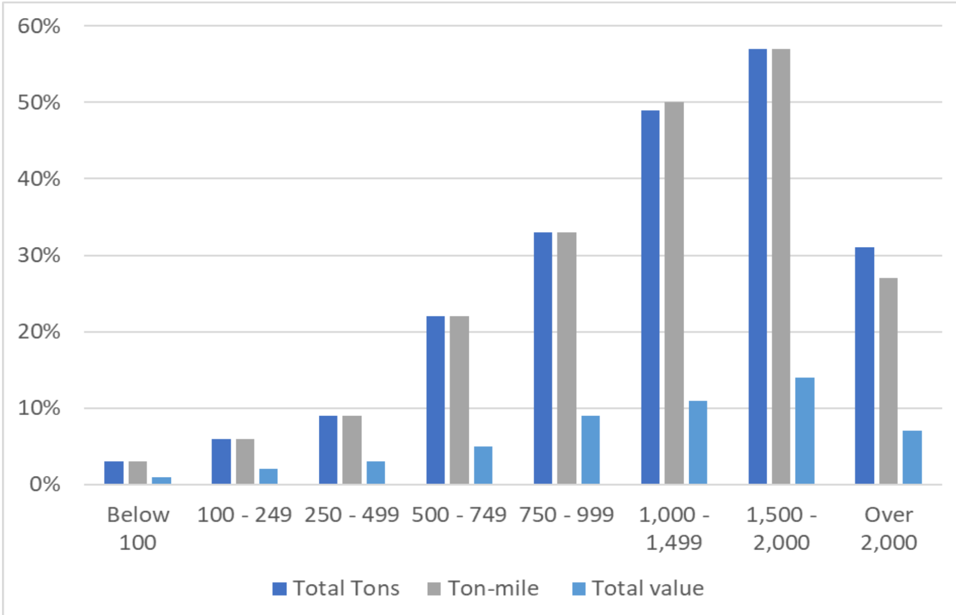

Figure 3.1 Share of Rail Transportation Within the U.S. Freight System.
Adapted from: (U.S. DOT, 2019)
*Data from 2017, Includes total flows: domestic, imports and exports

Rail was considered a competitive mode in the long distance trips (Behrends, 2012; Bitzan & Keeler, 2011). The U.S. Department of Energy determined that a truck to rail modal shift had the greatest potential for energy consumption reduction and it was a viable action because most freight trips are done by truck and rail serves many of the same routes (Brogan et al., 2013). The share of total tons, ton-miles and the value of goods transported by rail in different range of distances in relation to other freight modes was represented in Figure 2.1. Rail had a larger share of the transportation in the longer distance trips, accounting for around 50% of the modal share in trips between 1,000 to 2,000 miles. Therefore, the DOE considered the longer distance trips of between 250 and 750 mile range the trips where rail could be a competitive option to truck transportation when considering time and costs (Brogan et al., 2013).

Transport time and cost were characteristics that can make rail competitive over other more polluting modes (Brogan et al., 2013). Cost characteristics were not included as part of this research; therefore, improvements proposed were related to reducing transportation times.

3.5.1.1 External Operations

External Operations refers to operations improvements that require a company's cooperation with external companies such as other freight carriers and customers. In addition to companies' individual efforts to reduce emissions, cooperation with external companies to transport together the same volumes in fewer, fuller loads, was seen as an important aspect to improve energy efficiency (Mathers, Norsworthy, & Wolfe, 2014). Aspects that can be improved were:

- Network cooperation, cooperation with other freight carriers such as other Class I railroads, short-line railroads and other transportation modes such as truck, water and air transportation. Network cooperation refers to the synchronization of operations between the railroad and other transportation operations by minimizing delays and aligning timetables (Smokers et al., 2014). Additional benefits include the expansion of rail capacity (when cooperating with other Class I railroads and with short-line railroads), and the capacity to offer networks with service to all parts of the country (when cooperating with other transport modes) (Mathers et al., 2014). Network cooperation can be measured as miles traveled in a collaborative network, as coordination of operations in shared tracks (with other rail companies) (Smokers et al., 2014); and,
- Coordination with customers and with third party logistics providers. Coordination with customers is mentioned specifically when implementing 'precision scheduled railroading' (PSR) model. When operating under the PSR model, greater coordination with customers is required as trains operate under strict schedules and customers need to adapt to the railroad's timetable as opposed to the railroad adapting to the customers timetable and or delaying trains departure (Sniden, 2019). An example of a logistics company in northern Europe coordinating intermodal freight with customers helped reduce CO_2 emissions (Lammgård, 2012).

3.5.1.2 Internal Operations

Internal operations refer to companies' individual efforts to improve their energy efficiency. Improving energy efficiency and reducing fuel consumption goes hand in hand with improving operations management. Operation's improvement can be directed at railyards operations (i.e.: reducing the amount of time cars spend at terminals), operations along tracks (i.e.: reducing idling times), and improving locomotives' maintenance. Aspects that include internal operations are:

- Operations in railyards: Improving operations in railyards by applying lean principles has been studied to increase the capacity of existing facilities (Dirnberger & Barkan, 2007; Fakoor, Mehranfar, Bagheri, & Ahmadi, 2019; Otto & Pesch, 2017). Researchers have identified several bottlenecks (cars can spend more than 50% of their transit time in railyards (Dirnberger & Barkan, 2007; Fakoor et al., 2019), which vary depending on the type of terminal being studied (i.e.: intermodal facility, railyard, specific terminals). The most common bottlenecks mentioned in the literature are: 1) In railroad classification terminals, Dirnberger and Barkan (2007) found that the biggest bottleneck was the train assembly process. This consists of blocks of cars pulled from classification tracks and put together forming outbound trains ready for departure (Dirnberger & Barkan, 2007). 2) A second bottleneck identified was the gate-in process which refers to the time arriving trucks take to enter a terminal. Having no standard communication mechanism between truck drivers and the intermodal facilities lead to excessive variation in the processing times (Olesen, Powell, Hvolby, & Fraser, 2015). 3) A third bottleneck was the container storage area, as some containers might require moving for others to be taken out. Improvements can be achieved with the development of a standardized process such as a coding system to operate container trackers (Olesen et al., 2015).
- Implementing information technology (IT) systems: IT systems are used to manage operations in railyards and along tracks. IT systems can help manage the three bottlenecks mentioned in railyards: supporting the train assembly process, facilitating the arrival of truck to the railyard or intermodal facility and organizing containers and cargo within a facility (See Dirnberger & Barkan, 2007; Fakoor et al, 2019, Olesen et al, 2015). IT systems in railyards can also assist with the improvement of railroads' operating plan which includes the planning of equipment management, by improving equipment utilization, improving scheduling, and the planning of service design and maintenance (reducing operating and maintenance costs) (Bryan et al., 2007). Along railroads, improvements can be related to traffic control (operation of locomotives from a management perspective and

effective management of shared tracks). Overall improvements lead to railroads being able to improve reliability and increase capacity.

- Driver education is required in the management of train control systems designed to reduce braking losses and maintain optimal speed profile for fuel burn. Electrical devices can calculate the best speed and advice on reducing braking loses, but it is the driver who will operate the locomotive as optimally as possible (Gunselmann, 2005). Efficient driving was also mentioned as a challenge for on-time arrivals (Brecher, Sposanto, & Kennedy, 2014);
- Increasing trains' energy efficiency by effectively arranging and distributing locomotives and cars along the train. Reducing and maintaining the same gap length between cars, and avoiding empty slots reduced aerodynamic coefficient and hence reduced train resistance. This effect is important especially when traveling at high speeds (Barkan, 2007). Additionally, trains' energy efficiency can be improved by distributing locomotives in the middle and at the ends of a train. Locomotive distribution along a train could increase energy efficiency by 4% to 6% (Brecher et al., 2014).
- Increase of miles/ton travelled, which could be achieved by increasing load factors (operating longer and/or double stalked trains). IT systems and coordinating information with other transport providers helped achieve this goal (Gunselmann, 2005).
- Maintenance: lubrication improvement could have a significant impact in energy savings. Locomotives lose energy in wheel-to-rail friction. Friction could be reduced with improved lubrication; the estimated reduction in energy efficiency is 4% (Frey & Kuo, 2007).

3.5.2 Technology Innovations to Reduce Air Emissions

Technology strategies will modify, replace or enhance a system or equipment or its fuel to reduce air emissions (Frey & Kuo, 2007). Technology innovations focus on improving engines' energy efficiency, on the use of alternative fuels in locomotives and on improving infrastructure.

3.5.2.1 Technology Innovations of Locomotive's Engines

According to predictions by the U.S. DOT, there is an expected increase of Class I railroads energy efficiency that can be achieved from engine's technology innovation of 15-20 percent the value in 2015 by 2030 (Brecher et al., 2014). Research carried out in the U.S. is mostly directed to reducing emissions regulated by the EPA (HC, CO, NOx and $PM_{2.5\ \&\ 10}$) to comply with U.S.

EPA's Tier 0 to 4 regulations (Bergin et al., 2012; Gould & Niemeier, 2009). However, reducing GHG emissions, although not currently regulated by any agency, has also become a priority (Bitzan & Keeler, 2011; Craig, Blanco, & Sheffi, 2013)

The U.S. DOT, analyzed best practices from different countries, including the U.S to reduce emissions from the rail industry (Brecher et al., 2014). The study identified several technology improvements that are available or that are not yet available, but have a promising future. The conditions of U.S. Class I railroads, were considered and since locomotives have a lifespan of 40 years on average, the recommendations were made for upgrading existing locomotives with newer technologies or for new energy efficient locomotives (Brecher et al., 2014). Possible improvements included:

- Equipment technologies and energy reduction devices: refers to locomotives' retrofits or upgrades to increase their energy efficiency. Improvements include: modernization of traction and propulsion system, modernization of air conditioning system, shut down and automatic engine stop/start systems (Brecher et al., 2014).
- Energy use monitoring and idle reduction control devices: refers to information technology systems that can be incorporated to locomotives. Systems include: locomotive engineer assistant display and event recorder (LEADER), event recorded automated download (ERAD). Trip logistics optimization software which optimizes a locomotive's speed profile (Brecher et al., 2014).
- Energy efficient locomotives: new locomotives, usually having a combination of electric and diesel engines. Some of the technologies mentioned are: dual power hybrid locomotive, hybrid electric locomotive (switcher and long haul); battery electric locomotive, efficient ultra clean diesel-electric locomotives; and gensets (switcher locomotives that can shut down automatically when in idling) (Brecher et al., 2014).

Other aspects mentioned in the literature:

- Weight reduction: reducing weight of locomotives and railcars has the potential to reduce fuel use. The weight of the car body can be reduced using aluminum and stainless steel technology, plastic and others. Other technologies used can be steel frame construction (Gunselmann, 2005). The estimated energy use reduction is 5% (Frey & Kuo, 2007).

3.5.2.2 Fuel Alternatives

The use and development of alternative fuels was also mentioned as key to achieve locomotives' air emissions reduction (Brecher et al., 2014). Overall, however, the use of alternative fuels reduced the emissions of some types of gases, but increased others. Alternative fuels mentioned in the literature as viable options were:

- Hydrogen fuel or fuel cell hybrid locomotives, could be used in both switcher and line-haul locomotives. Hydrogen fuel locomotives had their design based on a commercial diesel hybrid platform, and included batteries to drive electric traction motors. Hydrogen fuel locomotives were available, and were being tested, but they were not being used by Class I railroad companies (Brogan et al., 2013; Miller, Hess, Erickson, & Dippo, 2010).
- Natural gas locomotives had also been tested; however, they produced more PM, NOx and GHG emissions than the purely diesel locomotives (Brecher et al., 2014).
- Biofuels and blends with petro-diesel are important alternatives. Biofuels are developed from biological materials coming from plant or animal products (Brecher et al., 2014). Commonly, according to the DOT, conventional diesel can be used with a blend of biodiesel of up to 5 percent in any diesel engine locomotive. A few modifications to the engines are needed when using a diesel blend of between 6 to 20 percent biofuel and for higher percentage blends, modification to engines may be required (Brecher et al., 2014). A study testing biofuels blends of 5 percent and 20 percent with EPA approved bio diesel, in switcher and line-haul operations concluded that higher levels of blend were associated with lower levels of CO and PM, but higher levels of NOx (Shurland, Smith, Fritz, & Frey, 2014). However, it was recognized that emissions from biofuels were different depending on the type of locomotive used and the throttle notch they operate on.
- Ammonia (NH3) was also considered an alternative fuel option for locomotives. The gas is produced combining two of the most abundant chemicals: hydrogen and nitrogen in a reaction (Dincer, Hogerwaard, & Zamfirescu, 2012). Ammonia can be used in internal combustion engine and fuel cell systems locomotives and it was considered safer to use than other fuels (Hydrogen) because of its odor, its high dissipation rate when in the air and its low flammability range (it is considered non-explosive) (Dincer et al., 2012).

3.5.2.3 Infrastructure Improvements

Infrastructure investment and improvements refers to the track network and railyards construction and maintenance. The innovation of the track system which includes: the use of better materials, equipment designs and advanced track components, has helped improve the performance of railroad freight and cost reduction of bulk transportation (Bryan et al., 2007). Bulk transportation was achieved by heavy-haul railroading (use of larger cars, more powerful locomotives, and longer trains) and double-stack container trains (Bryan et al., 2007). Additionally, advancements in track technology have allowed to reduce maintenance costs even when heavier cars are being used for transport (Bryan et al., 2007).

In relation to new railyard construction, there are two different positions regarding the location and number of railyards required for efficient operations (reducing traveling times and increasing reliability and capacity). According to Behrends (2012) and Bryan (2007), centralization of intermodal operations in a single terminal is likely to increase truck-miles traveled. Therefore having multiple terminals strategically located throughout a region allows for a reduction in truck-miles traveled which can also reduce environmental effects (Behrends, 2012; Bryan et al., 2007). Railroads operating using Precision Scheduled Railroading (PSR), instead have reduced the number of railyards operating as part of companies' networks. Instead of following a hub and spoke system where cars enter a hub to be re-organized in different trains, freight trains followed a point-to-point method, where cars were taken directly to their destination. The point-to-point haul method in addition to the strict schedules railroads operating under PSR have to follow, has allowed railroads to reduce the amount of time trains spend in terminals, increase their traveling speeds and decrease dwell times (Snider, 2019). For the purpose of this research, railyard investment whether in upgrades or building new facilities were considered a positive measure.

3.5.3 Summary of Actions to Reduce Air Emissions from Class I Railroad Companies

Several strategies to reduce emissions and increase capacity were mentioned. Operational strategies included improving operations in railyards reducing bottle necks, using IT systems and educating drivers to reduce energy consumption. Technical aspects mentioned were improvements to locomotives engines, use of biofuels and having infrastructure that will facilitate operations.

3.6 Factors Affecting the Adoption of Actions

Factors affecting the adoption of actions were taken from research that analyzed the implementation of actions by LSPs. There are different classifications of factors mentioned in the literature: drivers and barriers: (factors affecting the adoption of green initiatives either positively or negatively) (Centobelli, Cerchione, & Esposito, 2017; Evangelista et al., 2018), or organizational aspects (i.e.: management involvement, and the general environmental culture of the company); market related elements (pressure from customers and stakeholders); and government intervention (regulatory pressure) (Evangelista et al., 2018).

Factors mostly mentioned as affecting the implementation of strategies were: 1) Cost-related, implementing aspects that will reduce operating costs, or aspects that will increase companies' profitability (Evangelista, 2014; Obenhofer & Dieplinger, 2014; and Evangelista et al, 2017); 2) Having support from the government or pressure from regulations (Gonzalez-Benito & Gonzalez-Benito, 2005; Lin & Ho, 2010; Colicchia et al. 2013 and Evangelista, 2014); 3) Having support from the internal management of the company and environmental awareness of employees (Lieb & Lieb, 2010; Lin & Ho, 2010 and Evangelista, 2014); and 4) Pressure from customers (Lieb & Lieb, 2010; Obenhofer & Dieplinger, 2014, Evangelista et al, 2017). Factors here presented are classified as: organizational aspects, market-related elements, government intervention and other factors. In Table 3.5, a list of the factors with the authors that analyze impacts in their studies has been included.

3.6.1 Organizational Aspects

The level of priority given to reducing emissions was considered important for companies to achieve positive results (Evangelista, Colicchia, & Creazza, 2017). Companies' environmental commitment can be reflected in their organizational structure, culture and in their environmental strategy (See Evangelista et al. 2017). Lin & Ho (2011) found that a top management was key in organization support, as green initiatives are usually encouraged from the top. Management support also gives employee's motivation and resources (such as learning and training programs) to adopt environmental practices (Lin & Ho, 2011). When employees were aware of environmental issues and considered them a priority, they tended to make decisions in favor of the environment.

Some aspects that could be measured were: learning and training programs; and rewards to employees.

Table 3.5: List of Research Related to Factors Affecting the Implementation of Environmental Practices of LSPs.

Classification	**Sub-Theme**	**Authors**
Organizational Aspects	Internal organization structure / environmental awareness	Lin & Ho (2011); Salhieh & Abushaikha (2016); Evangelista et al. (2017)
	Desire to do the right thing / enhance image (strategy)	Lieb & Lieb (2010); Herold & Lee (2017b)
	Company Size	Ciliberti et al. (2008); Lin & Ho (2011); Obenhofer & Dieplinger (2014); Piecyk & Bjorklund (2015b)
Market-Related Elements	Pressure from customers	Gonzalez-Benito & Gonzalez-Benito (2005); Lieb & Lieb (2010); Colicchia et al. (2013); Salhieh & Abushaikha (2016); Evangelista et al. (2017)
	Pressure from competitors	Gonzalez-Benito & Gonzalez-Benito (2005); Lieb & Lieb (2010); Colicchia et al. (2013); Evangelista et al. (2017)
	Engagement with stakeholders	Lieb & Lieb (2010); Herold & Lee (2017)
Government Intervention	Government regulation / headquarters location	Gonzalez-Benito & Gonzalez-Benito (2006); Lin & Ho (2010); Colicchia et al. (2013); Piecyk & Bjorklund (2015b); Salhieh & Abushaikha (2016)
	Support to green initiatives by government / lack of funding	Lin & Ho (2010); Evangelista (2014); Evangelista et al. (2017)
Others	Cost reduction / increase profitability	Evangelista et al. (2017)
	High investment cost (barrier)	Evangelista et al. (2017)
	Use of a report framework / report type	Ciliberti et al. (2008); Piecyk & Bjorklund (2015b)
	Technological factors (green practice advantage, compatibility and complexity)	Lin & Ho (2011)

A company level of priority given to environmental sustainability can also be reflected in their formal environmental strategy (Herold & Lee, 2017b). Lieb & Lieb (2010), found a positive relationship between developing a formal sustainability statement and implementation of green initiatives in third party logistics providers (3PLPs). However, this idea has not been confirmed in recent research. Evangelista et al. (2017) in their study considering medium-sized logistics service providers (LSP), did not find a pattern in companies having a strategy and the type of initiatives implemented. Regardless of whether 3PLPs have or do not an environmental strategy, companies adopted a wide-range of green initiatives.

There were different opinions in relation to how company size encouraged the implementation of green initiatives. Research for the most part agreed that larger companies were better positioned and more capable of allocating resources for CSR reporting. Researchers found that, larger companies implemented more initiatives than smaller ones (Ciliberti et al., 2008; Lin & Ho, 2011; Piecyk & Björklund, 2015b). However, Obenhofer & Dieplinger (2014) who analyzed factors that influence the implementation of green initiatives of logistics and transportation companies, showed that company size was the least important factor encouraging green initiatives implementation out of seven factors analyzed. Company size was measured by number of employees and/ or total revenue.

3.6.2 Market Related Elements

Market-related elements can be classified in: pressure from different stakeholders, government and non-government stakeholders that affect a company's performance (Gonzalez-Benito & Gonzalez-Benito 2005). This section includes pressure from non-government stakeholders.

González Benito & González Benito (2005), studied the role of stakeholder pressure in the implementation of environmental practices in logistics practices from different companies. Non-government stakeholders included: customers, suppliers, employees, shareholders, financial institutions, communities, non-government organizations, competitors and media agents. Researchers found that perceived pressure from non-government stakeholders had a greater significant influence in companies' implementation of environmental logistics practices than perceived pressure from government (p.1367).

Within non-government stakeholders, customers were considered as having significant pressure in companies to adopt green initiatives (Lin & Ho, 2011). Evangelista et al. (2017), found that customers' pressures was the main driver in the implementation of environmental initiatives. When customers had a high level of environmental awareness, they could drive initiatives to increase the environmental sustainability of the supply chain. However, customers' lack of knowledge was also considered a barrier for implementing sustainability practices. Other studies found that although not the most important driver, customers were important in the implementation of green initiatives (See Lieb & Lieb, 2010; Colicchia et al., 2013; Evangelista 2014; and Oberhober & Dieplinger, 2014). Customers' pressures to implement green initiatives was measured in interviews or surveys; however, Piecyk & Björklund (2015b) considered public listing as a form of stakeholder pressure. Companies which made their reports available to the public were more visible to the media and had more public scrutiny, and thus were more like to voluntary report on environmentally sustainable practices (Piecyk & Björklund, 2015b).

Finally, several studies showed that pressure from competitors were not a big driver in the implementation of green initiatives (See Evangelista, 2014; González-Benito & González-Benito, 2006; Lieb & Lieb, 2010).

3.6.3 Government Intervention

Policies can be efficient in encouraging transport freight transportation providers to reduce their environmental impact. Support from government and pressure from regulations were the main motivator driving the implementation of green initiatives in two studies (Colicchia et al, 2013 and Evangelista, 2014). Other studies (Lin & Ho, 2011; Oberhofer & Dieplinger, 2014; Piecyk & Björklund, 2015b) mentioned that regulations and government support were essential; however, it did not point at government intervention as being the most important factor affecting the implementation of initiatives. Regulatory pressures can be a main motivation to implement environmental sustainability initiatives; however, when there was lack of clear regulation and bad communication about incentives, implementation became harder. In fact, lack of a well-defined regulations framework acted as a barrier for the implementation of green initiatives (Evangelista, 2014). Also, Piecyk & Bjoklund (2015b) found that companies tended to comply with the regulations and legislation from where they operated. There was no relation with reporting and the location of a company's headquarters.

In addition to government regulation, Herold and Lee (2017b) found that active stakeholder engagement was an indicator of commitment to reduce a company's environmental impact. Forms of stakeholder engagement mentioned were: 1) direct work with policy makers in the engagement of climate-change activities (i.e. collaboration in the development of energy efficiency standards); and, 2) funding of research organizations (many research funding projects were related to reducing reliance on fossil fuel while increasing the use of electricity as an energy source) (Herold & Lee, 2017b).

3.6.4 Other Factors

Cost reduction and the fact that companies used a specific report (GRI, CDP, SASB), were also aspects that were found to influence the level and scope of reporting. Obenhofer and Diepliger (2014) found that increasing profitability was the most important aspect for implementing green initiatives in transportation companies. Other studies Colicchia et al. (2011); Evangelista (2014) and Evangelista et al. (2017), found that although not the most significant factor, reducing company's operation costs and increasing profitability were significant reasons why companies choose to incorporate environmental initiatives. At the same time, high investment costs and doubtful payback about green investment were important reasons companies believed to be hindering the implementation of green initiatives (Evangelista, 2014). Finally, Ciliberti et al. (2008) and Piecyk & Bjorklund (2015b); found a strong positive connection in between the fact that companies used a report or not and the number of initiatives they reported on.

3.6.5 Summary of Factors

There were different results related to which factors researchers considered were influencing companies the most to implement environmental sustainable strategies. Some of the factors mostly considered in research were government intervention, company size and reducing costs. The next chapter includes a review of methodologies used in research that studied aspects companies incorporated to reduce their emissions or to be more sustainable. Methodologies used varied from surveys to company employees to obtaining information only from the reports.

3.7 Methods of Research Design Adopted in this Field

Studies that aimed to identify how the logistics and transportation industries have reduced their environmental impacts and factors that were affecting such changes have mostly been based on quantitative methodologies (Centobelli et al., 2017; Evangelista et al., 2017; Marchet et al., 2014). The most used methods were questionnaire surveys (about 45% of the papers) followed by case studies (between 15-20%). Other methods used were mathematical models, theoretical and conceptual research; and mixed methods (Centobelli et al. 2017; Evangelista et al 2018). There were also several studies identified in which there was no specific research method mentioned, only a list of steps that were taken to answer the research questions was mentioned (See Ciliberti et al., 2008; Lambrechts et al., 2019).

Questionnaires and surveys were used to determine factors that were affecting the implementation of green initiatives by obtaining the point of view from a company's managers or executive officers. Questionnaires were used when researching large numbers of companies (see Gonalez-Benito & Gonzalez-Benito, 2006; Lieb & Lieb, 2010 and Lin & Ho, 2010). Lieb & Lieb (2010), for example, used surveys when studying the commitment of LSPs to sustainability. The surveys were designed to understand companies' commitments towards their sustainability goals and their continuity after the economic recession of 2008 (Lieb & Lieb, 2010).

Colicchia et al. (2013), Evangelista (2014), and Evangelista et al. (2017), in their research, used case study analysis to identify environmental initiatives companies are implementing, and factors affecting the adoption of those initiatives. Firstly, researchers in the three examples analyzed companies' documents such as environmental reports and company websites to determine the green initiatives being implemented by LSPs. On a second stage, researchers held interviews with authorities to explore the drivers behind the adoption of initiatives. Overhofer & Dieplinger (2014) used the case study method, but focused only on identifying factors influencing the implementation of environmental practices. Similar to the previous examples, the researchers used different sources of information: interviews with companies' authorities and analysis of secondary data (reports, companies' websites, etc.) to triangulate information.

Content analysis was mentioned as a method when the focus was to analyze company documentation (See Herold & Lee, 2017b; Massaroni, Cozzolino, & Wankowicz, 2016; Piecyk & Björklund, 2015b). Content analysis was applied in three stages: 1) Development of a framework; 2) Data coding against the framework, and; 3) Data analysis and comparison to additional qualitative characteristics. Piecyk & Bjorklud (2015b), for example used content analysis to identify CSR indicators covered in LSPs sustainability reports and factors influencing the level and scope of reporting. Authors examined corporate websites and CSR reports, using the GRI questionnaire as the base framework to categorize the themes from reports. Finally, results from the coding were compared to different aspects: company size, headquarter location and ownership structure. Herold & Lee (2017b) used interpretive content analysis to get an in-depth insight into the reporting behavior of companies. Instead of using an existing framework, the authors developed a framework which identified the different types of reporting behavior (symbolic or semantic) and their characteristics. Strategies, motivation and commitment towards global warming and climate change were identified from report's company statements.

Ciliberti et al. (2008) and Lambrechts et al. (2019) did not specify a specific methodology in their research. Both authors followed similar steps to identify most common practices that companies were reporting on to become more socially responsible and more sustainable respectively. In both cases, researchers developed a framework from the literature review and from reports where information was collected from. Frameworks were later used to identify practices adopted by each company (Ciliberti et al., 2008; Lambrechts et al., 2019).

Overall, case studies and content analysis methods were used to answer similar types of questions as this researcher's objectives. Case study method was justified as it was acknowledged to gain a deeper understanding of a phenomenon and because it allowed the comparison of two or more companies (Evangelista et al., 2017). Case study method was used to identify practices implemented by 3PLPs (reviewing companies' documentation) and factors affecting the implementation of those practices (through interviews) of a small number of companies. Content analysis method was useful to determine key ideas and themes published in text (Piecyk & Björklund, 2015b). Content analysis was used when relying on obtaining all data from written documents to identify green practices being implemented by companies. A few authors however used content analysis or relied only on written documentation to identify factors that may be affecting the level of implementation (Ciliberti et al., 2008; Herold & Lee, 2017a; Piecyk & Björklund, 2015b).

3.7.1 Philosophical Foundations of Research

Qualitative research can be approached in different ways depending on its purpose. The beliefs and the aims of the research are associated with the core philosophies of science which are foundational assumptions about the nature of our world. The varying approaches are ontology, epistemology and axiology (Leavy, 2014). The difference between the three are the way in which the researcher sees the world or how his/her beliefs might influence research interpretations.

Ontology refers to the study of the nature of reality. There are two extremes in which reality can be seen under this theory realism and nominalism (Leavy, 2014). Under the realist theory, researchers believe there is a universal truth about the reality that we know. Reality is tangible, concrete and stable, regardless on people's perceptions. Under nominalism theory instead, ideas and phenomena are considered to be just words and labels, and have no real existence outside our imaginations (Miller, 2005). Epistemology is concerned with the process of finding out how we know what we know and the relationship between the knower and the world (Leavy, 2014). There are also two extremes in this theory: objectivism and subjectivism. Objectivism refers to the notion that it is possible to understand the world and build knowledge progressively without bias (Miller, 2005). Under this view, researchers apply several mechanisms such as the scientific method, to reduce researchers' bias in their studies (Leavy, 2014). Under a subjective view, researchers accept that the social world is only possible to understand through the researcher's point of view (Miller, 2005). Under a subjective view, the interaction between the researcher and the participant becomes important to capture the experiences of the participant (Leavy, 2014). The last philosophical foundation of research is axiology, which is concerned on how the values of the researcher influence the scientific process (Leavy, 2014). The two extremes under this theory are "none" and "a lot". On one extreme, philosophers believe it is not possible nor desirable to separate values from the research process. On the other extreme (a lot), it is believed that it is impossible and undesirable to separate values from the truth (Miller, 2005).

3.7.2 Research Paradigms

Considering the previous "core philosophies of science" research can be carried out using different approaches to each of them. Research will have a certain assumption to the reality of the world (ontology), knowledge about the world (epistemology), and a degree of influence from the researcher' own values (axiology) (Leavy, 2014). The combination of these philosophies has led to the identification of research paradigms, which can be used to guide the structure of qualitative research (Leavy, 2014). Paradigms embody different philosophical positions used for research that represent different ideas about reality, and that are used as a way to gain knowledge (Creswell, 2009). Using a well-known paradigm will help clarify the researcher's decisions about the research's framework or design. Additionally, the type of paradigm (beliefs) held by a researcher will also determine the type of method chosen: qualitative, quantitative or mixed methods (Creswell, 2009).

There are many paradigms considered by researchers, and yet, not all research can fall just in one paradigm but may have ideas of several (Maxwell, 2013). Researchers mentioned different classifications of paradigms based on their core philosophies. Miller (2005) mentioned five main paradigms: positivism, post-positivism, interpretivism, critical theory and postmodernism. Creswell (2005) mentioned four paradigms: post-positivism, constructivism, advocacy and participatory; and pragmatic. Patton (2015) mentioned 17 different paradigms classified based on their foundational questions. In this research, attention was given to the paradigms mentioned in the literature for the analysis of CSR reports using content analysis method.

3.7.3 Content Analysis

This study aimed to investigate aspects that seven Class I railroad companies were reporting in their yearly CSR reports, and aspects companies were reporting to reduce current emissions. Additionally the aim of the research was to identify factors that could be affecting the implementation of those actions. Based on previously used methodologies, content analysis method was selected to be used to answer the proposed questions.

Content analysis method is used to examine and interpret qualitative data, which refers to particular forms of communication such as written documents, interviews, video materials, and images (Berg, 2009). There are different types of content analysis (See Drisko & Maschi, 2015 and Berg, 2009) which are classified based on the level of interpretation required from the researcher when analyzing the data. Although not all authors talked about different types of content analysis. Krippendorf (2013), refered to only one type of content analysis and described it as: "*a research technique for making valid inferences from texts (...) to the contexts of their use*". Still, the classification serves as guidance for the researcher to identify the level of data interpretation required and the possible bias that could occur because of the interpretation.

Drisko & Maschi (2015) classified content analysis in basic, interpretive and qualitative. The first, basic content analysis requires little interpretation from the researcher. Data analysis can be a mere count of specific topics or the frequency items such as words, topics or paragraphs, which will be classified on the previously defined categories (Lambrechts et al., 2019). This type of content analysis has been argued to be superficial or form-oriented since it is mostly concerned with counting (words or themes) rather than with interpreting the meaning of a text (Vourvachis & Woodward, 2015).

The second type, interpretive content analysis still requires categories to be deducted from the theory, and the analysis is mostly a quantitative process. However, the process under this type of content analysis requires a semantic interpretation of the text from the researchers (Vourvachis & Woodward, 2015) (a semantic interpretation refers to a direct interpretation of the meanings of words and symbols). Finally, qualitative content analysis is mentioned as similar to the previous, it requires an interpretation from the researcher of the text or symbols, based on the researcher's understanding of the text (a pragmatic interpretation of text) (Vourvachis & Woodward, 2015). Results from research that has applied the most basic form of content analysis is usually presented using basic statistics while results from interpretive and qualitative content analysis is presented as either quantitative or qualitative information (Drisko & Maschi, 2015).

3.7.3.1 Paradigms Applied to Content Analysis

Different types of content analysis draw from different paradigms. Basic or form-oriented content analysis draws on standard positivist or realistic paradigms. Researchers' personal beliefs and biases are not viewed as influencing the results since data coding focuses on the superficial rather than on a deeper meaning of the text (Vourvachis & Woodward, 2015). Interpretive or meaning oriented content analysis, instead, follow a constructivist or interpretivist foundation (Drisko & Maschi, 2015). The interpretivist paradigm assumes that people seek to understand the world they live in and work; and meanings are interpreted or constructed differently by every person (Creswell, 2009). Patton (2015), mentioned three ways in which operating from a constructivist paradigm affect research: 1) The idea of having multiple realities reflected on the researcher's interpretations of reality; 2) The different perspectives of a reality presented by each participant of the study, and 3) multiple realities are represented in having flexible guidelines (qualitative methodologies tend to be malleable) (Patton, 2015).

Krippendorff (2013) applied these ideas to content analysis research and argued that: 1) Researcher's biases can influence outcomes as printed matter, visual communications, etc., have no meaning by themselves, but require the interpretation from an analyst to make sense of them (p. 28-30). Texts' therefore, are given meaning from the perspective and understanding of the reader. (Drisko & Maschi, 2015); 2) Texts have no single meanings, and data can be analyzed from different perspectives. For example a text can a have a political, psychological or economic interpretation. While all interpretations can be valid, at the same time, they can all be different (Krippendorff, 2013). Overall, no matter how much researchers try to be objective with their interpretations, the context under which documents are analyzed will always be constructed by someone (Krippendorff, 2013).

To avoid bias, and for content analysis to be replicable, there are three aspects that were mentioned should be considered when using content analysis method: 1) Identify possible researchers' bias. 2) Analysis must choose a context that will guide the interpretation of documents. The context refers to the disciplines and the reasons researchers have for interpreting a particular text (Krippendorff, 2013); 3) Coding should be very specific and a researcher must ensure all analysis have a clear understanding of the coding scheme (Krippendorff, 2013). Vourvachis & Woodward (2015) mention that it is of particular concern that very few researchers include detailed examples of coding rules and guidance for future researchers that will help ensure replicability.

3.7.4 Quality of Research Design in Content Analysis

Research design is supposed to present reliable statements so that the quality can be judged based on different topics (Yin, 2014). Topics used to measure the quality of research in content analysis are reliability and validity (Krippendorff, 2013). Reliability refers to the extent in which studies can be replicated (Vourvachis & Woodward, 2014). Reliable information can be replicated regardless having variations on the measuring process, instrument or person (Krippendorff, 2013). Validity refers to how well a study mirrors reality (Vourvachis, & Woodward, 2014). In content analysis, a study is said to be valid if it measures what is says and if there are no logical errors in drawing conclusions from the data (Drisko & Maschi, 2015).

Krippendorff (2013), mentioned three types of reliability: stability, replicability and accuracy. Stability measures the extent to which the measuring or coding procedure gives the same results on repeated tests. Stability can be measured by having one person recode or reanalyze the same data after some time has passed (Krippendorff, 2013). Replicability refers to the extent to which different researcher can obtain the same results when analyzing the data under varying conditions, but with similar instruments (Krippendorff, 2013). Replicability can be tested by having two analysis coding information and obtaining similar results. Finally, accuracy, refers to the degree in which a process aligns with specifications and the results are what they are intended to be. The accuracy test is performed by comparing results obtained against a given standard that is considered to be correct (Krippendorff, 2013). From the three types of reliability, stability according to Krippendorff (2013), is the weakest form, while accuracy can be considered the strongest test available. Stability and replicability are the most common tests of reliability performed in the analysis of environmental reports (Lambrechts et al., 2019; Larrán, Andrades, & Herrera, 2019; Lindholm, 2010; Piecyk & Björklund, 2015b).

Validity has been interpreted in many different ways (Webber, 1988). Krippendorff (2013) proposed a complex classification of validity. At a broad level, the classification included: face, social and empirical validity. Face validity is a 'common sense' test, it is argued that we accept the results of a test because they make sense. Social validity refers to the quality of the research being of important social concerns and leads people to accept results as contributing to the public discussion. Empirical validity has a further classification as it refers to the degree in which each stage of the research process is supported by theoretical evidence. Aspects part of the empirical validity test include the sources to be analyzed when developing the coding schemes, sampling units, context units and measurement units (Krippendorff, 2013).

Weber (1985), explained that validity applicable to content analysis is related to two aspects: 1) the validity of the classification scheme, and 2) the interpretation related to those variables (Weber, 1985). The classification by Weber (1985) was also mentioned by Vourcachis & Woodward (2014). Validity of the classification scheme was also referred as internal validity. Under internal validity, the coding scheme (framework) should measure what it claims it measures. Larrán et al. (2019) guaranteed internal validity selecting a framework that is widely recognized (GRI). Lambrechts et al. (2019) instead, ensured internal validity by confirming each indicator included in the framework had at least two references. Validity of the interpretation of content was also referred as external validity. Inferences drawn should be able to inform successful actions, or should be generalizable (Vourcachis & Woodward, 2014). External validity in several studies was ensured by analyzing a large number of reports so that results were consistent (Lambrechts et al., 2019; Larrán et al., 2019).

3.7.5 Content Analysis Applied to the Evaluation of CSR and Environmental Reports

Content Analysis is a common research method used when analyzing companies' CSR and environmental reports. Examples of CSR analysis from the literature, mostly used an interpretive and/or qualitative content analysis method, which required interpretation from the coders at various degrees. Research was usually carried out in three stages: framework selection, data coding, and comparison of results to factors that may be affecting the level of reporting.

Data analysis strategies of studies that analyzed CSR or sustainable reporting was taken from different research examples from literature. The methodology of eleven studies that analyzed the reporting of different types of industries using content analysis as the main research method were considered. Most of the examples were taken from studies of LSPs, only four of the examples were from other industries (banking, universities and public sector organizations).

3.7.5.1 Framework Selection

First, researchers selected a framework that was used during data collection to identify items from reports. The framework was either developed from the literature review, an existing framework from previous studies was used, or the questionnaire of an existing report such as the GRI was used. Lambrechts et al. (2019), for example, developed a sustainability matrix based on the literature review to identify sustainability aspects reported by LSPs. Piecyk & Bjorklund (2015b), instead, used the GRI reporting questionnaire as the base framework to categorize the different themes from reports in their studies. Because the GRI is the most commonly framework used as it is considered the most accepted reporting scheme worldwide, the authors decided to enhance it rather than propose a new one (Piecyk & Björklund, 2015b).

3.7.5.2 Coding

Data from the reports was coded and classified using the framework. Most examples used a simple yes/no rating system to identify indicators that were implemented from those that were not (See Piecyk & Bjorklund, 2015b and Lambrechts et al., 2019). Although, not all indicators have the same impact, the yes/no rating method was commonly used because it was difficult to determine the exact impact of every indicator (See Colcchia et al., 2011, and Colicchia et al., 2013). A few studies did classify information using a system with more variables (See Gallego-Alvarez et al., 2018 and Meng et al., 2012). Results of studies using yes/no answers to categorize information identified which aspects were considered by companies more than others. Studies with a wider categorization system, however could identify more accurately levels of reporting between companies (See Meng et al., 2012). Examples of both forms of categorization are explained bellow.

Researchers used different approaches to count indicators when categorizing information based on simple yes/no answers. Colicchia, et al. (2011), and Colicchia, et al. (2013), for example, counted indicators that were adopted by the companies. Piecyk & Bjorklund (2015b), instead, only considered indicators reported that were measurable (i.e.: CO_2 emissions reduced by 10%), non-measured items were not counted as implemented. Ciliberti, et al, 2008, counted every time an indicator was mentioned, in order to record the frequency each indicator mentioned.

Examples of coding that included more than two categories are found in the studies by Gallego-Álvarez et al. (2018) and Meng et al. (2012). Gallego-Álvarez et al. (2018) classified information dividing it in three groups, assigning values of 1, 0 or -1. The 0-value was used to indicate the lack of information provided by the company. The 1-value was assigned to variables that had a positive outcome favoring the environment, while a value of -1 indicated a negative outcome that negatively affects the environment (Gallego-Alvarez, Lozano, & Rodriguez-Roca, 2018). Meng et al. (2012) coded information classifying it in four groups and giving it values of 0 to 3. The classification was made based on the level of disclosure provided, "0" value was assigned when no information was given, 1 when a general description was given, 2 if the indicator was described specifically and 3 when the indicator was described in monetary and quantitative terms (Meng, Zeng, & Tam, 2012).

For statistical analysis, yes/no answers were assigned a value of 1 to indicators that were present, and a value of 0 otherwise. Analysis of indicators implemented was carried out using simple math such as percentages and averages. Results related to the indicators companies were reporting on were divided in categories as per the framework applied, i.e.: organizational practices, managerial practices, environment, diversity, etc. (See Ciliberti et al., 2008). The percentage within each category in addition to the percentage between all categories were presented in calculations (See Larrán et al., 2019).

3.7.5.3 Comparison with Factors Affecting the Level of Implementation

Similar to the objectives of this research, several authors compared preliminary results obtained in the first phase of the research with factors that may be affecting the implementation of those actions. Larrán et al. (2019), for example, analyzed a small number of sustainability reports (20), against several factors: size, location, public/private status, institutionalization, external assurance and leadership. The analysis was carried out performing non-parametric tests after data showed it was not based on a population with normal distribution. Results were presented comparing the different factors against indicators reported in each category. Piecyk & Bjorklund (2015b), analyzed the reports of 45 different companies. Reporting results were compared to the four main factors identified as likely to influence the level of CSR reporting (size of a company, geographical location of headquarters, pubic listing and the use of GRI framework to report, or not). ANOVA tests were used when data was normally distributed, otherwise, non-parametric tests were carried out.

3.8 Summary

In this chapter the review of literature was carried out. First a review of several reporting schemes where rail companies reported to in the past 10 years were described: GRI, CDP and SASB standards. Second, it was determined that current research based on CSR reporting analysis is lacking uniformity. More research by sector specific such as Class I Rail companies can help find trends in the reporting and aspects which companies consider important. Third, aspects that are important to address by the rail industry where mentioned which include the reduction of air emissions and capacity increase in order to help the freight system reduce its emissions. Aspects here mentioned were used to develop the proposed Freight Rail Framework to answer research question two. Fourth, aspects that might affect the level of reporting were mentioned. These include, company size, legislation and customer pressure amongst others. Finally, a review of the methodology used in similar-type research was carried out. Content analysis, the method used in this research was analyzed in more detail.

CHAPTER 4. METHODOLOGY

In this section, the steps the research followed are presented. The research questions are outlined followed by an explanation of the choice of the analysis method: content analysis. The research paradigm adopted is identified which includes an identity memo from the researcher. Following, the data collection process is explained which includes overview of the coding, data collection sources, frameworks used and measures to ensure the quality of the research. Finally, the factors that may be affecting the implementation of practices are described.

4.1 Research Questions

The three research questions are related to practices Class I railroad companies are reporting as being implemented to reduce air emissions during freight transportation:

1. What indicators have Class I railroad companies reported in their CSR reports during the past 10 years?
2. What practices have Class I railroad companies reported to reduce air emissions during the past 10 years?
3. What factors appear to be influencing the number of practices being reported by class I railroad companies to reduce air emissions?

4.2 Research Methodology

Content analysis method was selected to answer the study's research questions as the method has been used in similar type research (Lambrechts et al., 2019; Larrán et al., 2019). From the different types of content analysis: basic, interpretive and qualitative, an interpretive or meaning-oriented form of analysis was applied during the research. Interpretive content analysis, as previously stated requires a thoughtful and interpretive analysis of the documentation (Vourvachis & Woodward, 2015). In this case, the researcher interpreted and categorized information, even though information was not always mentioned as specific strategies to become "sustainable", to reduce air emissions or increase capacity. Interpretive content analysis according to the literature is used mostly in research that is descriptive in nature (Drisko & Maschi, 2015). In this research an interpretation of how companies were reporting form descriptions(companies' reports) was carried out.

4.3 Paradigmatic Stance of the Dissertation

Interpretive content analysis follows a constructivist or interpretivist foundation (Drisco & Maschi, 2015). Considering the ideas of Krippendorff (2013), when carrying out interpretive content analysis, researchers need to acknowledge that texts can have different meanings and different interpretations based on the context they are being analyzed under, and the analysts' own biases. In this case, both aspects have been clarified: the context in which the analysis was carried out and the researcher's biases.

4.3.1 Context of Analysis

This analysis was carried out in the context of identifying aspects rail companies were implementing to reduce their air emissions and increase capacity. Rail freight transport is considered part of the freight system of the U.S. As such, rail is the second least polluting option after water transport, and many claim, the strength of the rail system is that the increase of its use can help reduce the environmental effect of the entire freight system (Brecher et al, 2014; Mathers et al., 2014). Therefore, this research considered aspects carried out to increase Class I railroads capacity as positive indicators to reduce air emissions.

Additionally, within rail, the researcher identified technology and operational strategies as positive indicators that could help Class I railroads reduce air emissions. Strategies included technology improvements such as incorporating new more efficient locomotives, and operational improvements such as educating engineer conductors in driving efficiently.

4.3.2 Identity Memo

The identity memo reflects previous experience the researcher has had in aspects related to the research topic and beliefs emerged from that experience. Also, it contains a description of how previous experiences have shaped the researcher's decisions to choose this topic and the approach for the investigation.

Ideas related to subjects in sustainable freight transport and reducing emissions of transportation come from my previous studies and work experience. I studied Urban Planning and worked for the department of transportation planning in the city of Quito-Ecuador. I did my master's thesis related to sustainability in the public transportation system in my home city, Quito. That experience exposed me to the fact that environmental issues are crucial when monitoring sustainable transport. Transportation is the biggest source of greenhouse gas emissions in cities. Although 'sustainable development' is commonly defined as being concerned with environment, social and economic aspects, research related with sustainable transportation has determined that the environmental impact of transportation as in air emissions are the biggest source of concern. Reducing emissions is important to achieve a "sustainable transportation system".

Working for the department of transportation planning in Quito helped me realize that issues such as sustainability are still political and may not be in the agenda of governments. I am familiar with research from the 'urban planning' point of view (i.e., influencing people's behavior to choose one transportation mode over another and institutional arrangements that can influence behavioral changes). This research has allowed me to analyze environmental concerns from the point of view of private companies; how private companies are approaching environmental concerns and the type of aspects they are relying on to reduce their air emissions.

4.3.3 Study Sample

The seven Class I railroads operating in the United States were considered for the study. However, not all companies reported to the GRI or CDP during the years selected, KCS and BNSF were only included in the analysis of the first research question as the companies did not report to the CDP. Refer to Table 4.1 for a list of the reports used for each of the companies.

4.3.4 Data Collection Sources

Annual reports filed by companies to the GRI and to the CDP were used as sources of information to answer the first two research questions. Additionally, information from the U.S. Securities and Exchange Commission (SEC) (10-K for national companies and 40-F reports for Canadian companies) and/or companies' annual reports filed to the Surface Transportation Board (STB) were used to collect additional data such as: companies' number of carloads transported or revenue-ton miles. GRI reports were downloaded from the GRI or from the companies' web sites.

CDP and 10-K/ 40-F reports were available at the CDP and U.S. SEC web sites respectively. Finally, annual reports to the STB were available at companies' websites. Table 4.1 contains the list of GRI and CDP reports used.

The analysis was carried out with information from reports every two years given that not all companies report every year. Canadian Pacific and Canadian National only reported every two years on even years to the GRI since 2010 (except when indicated by CP). CDP's reports of odd years include information from the previous year, i.e., a report from 2011 contains data from 2010. Therefore, reports of even years from the GRI were used while reports from CDP's odd years were used.

Table 4.1: Class I Railroads, Reports from GRI, CDP and U.S. SEC Used in this Research

Report	**Year**	**KCS**	**CP**	**CSX**	**NS**	**CN**	**UP**	**BNSF**
GRI	2010	No	2009 *	Yes	Yes	Yes	Yes	No
	2012	No	2011 *	Yes	Yes	Yes	Yes	No
	2014	Yes	Yes	Yes	Yes	Yes	Yes	2013**
	2016	Yes	Yes	Yes	Yes	Yes	Yes	2015**
	2018	Yes	Yes	Yes	Yes	Yes	Yes	2017**
CDP	2011	No	Yes	Yes	Yes	Yes	Yes	No
	2013	No	Yes	Yes	Yes	Yes	Yes	No
	2015	No	Yes	Yes	Yes	Yes	Yes	No
	2017	No	Yes	Yes	Yes	Yes	Yes	No
	2019	No	Yes	Yes	Yes	Yes	Yes	No

* Canadian Pacific did not issue a CSR report in 2010, nor in 2012. Therefore reports from 2009 and 2011 were analyzed instead.
** BNSF did not issue reports in 2014 nor in 2018. The first report BNSF issued was in 2013, therefore reports from 2013, 2015 and 2017 were analyzed instead or reports from 2014, 2016 and 2018

To answer the first research question, information was collected only from the GRI reports and using the GRI framework. The second research question was answered using the proposed framework for data collection. Because companies did not directly address the indicators from the Freight Rail Framework, information from both reports, GRI and CDP were used as sources. Data collected from every report was recorded and kept in different tables, and once data from both reports was collected, information was combined in a third table. The reporting of every indicator was marked with 0, 1, 2 or 3 value, then, the highest value from the two tables GRI and CDP was assigned to a "combined" table. For example if "Network Cooperation" was not mentioned in the GRI report, but it was mentioned with a measurable outcome in the CDP report, a value of 1 was assigned to the final table. Results of the data collected was recorded as in presented in Appendices 4 and 5.

4.4 GRI and Proposed Freight Rail Framework

Previous studies have either developed a framework from the literature review (See Ciliberti et al., 2008), or chosen an existing one for categorization of information using content analysis as a research method (See Colicchia et al., 2011). To answer the study's first research question, the GRI standards that include the GRI's Logistics and Transportation Sector Supplement (LTSS) (2006) current at the time of writing were used as a framework. The GRI standards have been used in studies that analyze the reporting of logistics companies, as it is considered the most commonly used standards to report (See Lambrechts et al., 2019 and Piecyk and Bjorklund, 2015b). Using the GRI framework, allowed for comparisons with previous research. The list of indicators from the LTSS that were included in this research was presented in Appendix 2. A separate list containing indicators that were not incorporated as part of this research was also included in Appendix 2. Indicators not incorporated as part of the research were environmental ones related to types of products and services, transportation and congestion, as analyzed companies offer the same transportation service, and are the same for all. Other indicators not included are related to human rights issues as Class I Rail companies do not currently deal with those situations.

To answer the study's second research question, a framework, the Freight Rail Framework was developed based on ideas related to sustainable rail freight transport as found in the literature review. The review of literature was made using the Purdue Library system tool including online and paper-based resources. Key searched themes were: corporate socially responsible rail freight; sustainable rail freight; environmentally sustainable rail freight; and, rail freight emissions. The terms were used in different combinations, and the scope was expanded to include articles and books from references of the articles obtained as part of the initial search. Sources obtained are comprised of books and pier reviewed journal articles (For details of the Freight Rail Framework see Section 5.3.1).

Both frameworks were the main instruments used for coding and aspects of internal and external validity were considered. Internal validity referred to the degree in which the coding framework is supported by theory (Vourcachis & Woodland, 2014). The GRI framework was recognized by the research community as the best known framework for voluntary reporting (Lambrechts et al., 2019), therefore, no additional step was taken to ensure its internal validity. Internal validity for the Freight Rail Framework was ensured by having each aspect listed supported by at least two references as per Lambrechts et al. (2019).

4.4.1 Coding

Weber (1985), mentioned the need to define the recording units, define the categories and conduct a test coding on a sample text. Because the research was carried out based on an interpretive content analysis method, the coding system was related to the quality and quantity of the information presented in the reports. To answer the first research question, the coding was based on research by Gallego-Alvarez et al. (2018) and Piecyk & Bjorklund (2015b). Collected data was classified assigning values of 0 or 1 depending on the quality of information provided. This was carried out because the objective of the research was to identify in general what aspects from economic, environmental or social practices Class I Railroads were concentrating on when reporting. Additionally, because this coding was used in other similar research, comparisons were possible and carried out. The coding system to answer the first research question has been summarized in Table 4.2.

Table 4.2: Coding System to Answer the First Research Question

Value	Meaning	What to look for
0	No implementation of the indicator	- No mention of indicator - Brief explanation without a measurable outcome or measure of implementation
1	One or more projects implemented	- Brief explanation with an indicator - Detailed explanation without indicator

To answer the second research question, coding was based on the research by Meng et al. (2012). Because the objective was to identify in detail what companies were addressing to reduce their emissions collected data was classified assigning values of 0, 1, 2 or 3 depending on the quality and quantity of information provided. Categories from 1-3 were determined based on the number of projects companies implemented of each indicator. Each project had to include a measurable outcome or a detailed explanation of the project in order to be considered. Different aspects were considered measurable outcomes i.e., percentage stage of implementation, monetary investment, etc. The coding system to answer the second research question is summarized in Table 4.3.

The weakness of the coding systems was the fact that the codes were assigned based on whether the indicator was implemented or not. Measurements of the amount of effort (i.e.: monetary investment or amount of hours of employees training) put into each indicator were not considered. These were somewhat addressed in each question differently. In the first research question, lack of precision was reduced by ensuring a specific measurement or a detailed explanation of the indicator was offered. In the second question the four levels of coding based on the number of projects implemented also helped identify which areas a company was concentrating on to reduce emissions and increase capacity.

Table 4.3: Coding System to Answer the Second Research Question

Value	Meaning	What to look for
0	No implementation of the indicator	- No mention of the indicator - Brief explanation without a measure of outcome and/or implementation
1	1 project	- Explanation of the indicator implementation with a measure of outcome and/or implementation - Detailed explanation without indicator
2	2 projects	- Explanation of the two projects implementation with a measure of outcome and/or implementation - Detailed explanation of the two projects without indicator
3	3 or more projects	- Explanation of the three projects implementation with a measure of outcome and/or implementation - Detailed explanation of the three projects without indicator

4.4.2 Quality of the Research

Reliability which refers to the extent in which studies can be replicated (Vourvachis & Woodward, 2015) was ensured by having the researcher code all the information a second time after a few weeks had passed from the first collection. Data from the first and second rounds was collected in different tables with the purpose of comparing the information after the collection process was finalized. If the coding from the two periods did not match, then a review of the information was carried out a third time in order to determine the correct code for each indicator.

External validity refers to the consistency of results and the generalizability of the information obtained (Vourcachis & Woodward, 2015). External validity can be ensured by analyzing a large number of reports (See Lambrechts, et al., 2019 and Larrán et al., 2019). This study guaranteed external validity by analyzing reports of the seven Class I railroad companies reported to the GRI and CDP between 2010 and 2018. Class I railroad companies have reporting to the GRI and CDP between 2010 and 2018 either yearly or every two years.

4.4.3 Data Analysis

An adoption index (AI) and Quality Index (QI) were calculated to answer the first and second research question respectively. The AI was calculated as per similar research to analyze the first research question (See Ciliberti et al., 2008; Colicchia et al., 2011; Larrán et al., 2019). The AI represents a percentage of the number of indicators reported compared to the number of total indicators that may choose to adopt by each company. The AI was used to calculate overall implementation of indicators of each company from the GRI framework, and the implementation of indicators of the different sub-groups (i.e.: environmental, social and economic aspects from the GRI framework). The AI did not consider initiatives' degree of implementation nor the impact each of them has on reducing air emissions from freight transportation. The index was calculated using the following formula based on Colicchia et al. (2011):

$$AI = \frac{\sum Number\ of\ adopted\ indicators}{Total\ number\ of\ indicators}$$

QI was calculated based on the research by Meng et al. (2012), and Gallego-Álvarez et al. (2018) to answer the second research question. The QI represents the quality of the information provided by the companies in their reports. The QI was used to analyze data from the second research question which used the Freight Rail Framework to determine which aspects specifically companies are relying on to reduce air emissions and increase capacity. The index was calculated based on the following formula:

$$QI = \frac{\sum of quality\ value}{Number\ of\ indicators\ reported\ on}$$

There were different statistics calculated for both, the AI and QI. First an overall AI and QI was calculated for all companies through the years as an overall value to understand the reporting of Class I Railroads. Second, an AI and QI was calculated for each company as an average of the reporting period and for each year. The overall values per company were used as a comparison of the reporting per company through the years. The analysis per year was used to compare the results with different years and identify if companies have changed their focus during the study period.

4.5 Factors' Analysis

To answer the third research question, results from the two first research questions were compared to two factors found in the literature that could affect the implementation of practices: company size, and operation zone, the last one related to government policies and incentives. Companies were divided by size based on research by Piecyk & Bjorklund (2015b) where the total revenue was considered to measure size. Railroad companies were divided into three groups: large (revenues > $20 million), medium (revenue < $ 20 million, but > $ 5 million) and small (revenues < $5 million). The division was carried out in such way so that the difference between the large and small companies was significant. This way, if existing, differences in the reporting by size could be identified (UP and BNSF, the "large" companies are 10 times larger than the "small" company, KCS).

Division by operation zone was carried out by separating companies in two groups based on the location of their headquarters in: American and Canadian Railroads, as different policies or incentives were in place for each. Based on air emissions legislation, all companies had to comply with the emissions standards set by the EPA. However, Canada had additional requirements set in their Memorandums of Understanding (MoU). As for government support, it was also related to the country where companies belong. Tiger grants offered by the American government were directed at American companies while support in biofuels research offered by Transport Canada was only reported by CP and CN. The analysis was carried out considering AI or QI results grouping companies by company size and by location as per Table 4.4.

Table 4.4: Factors Affecting the Implementation of Practices

Railroad Company	**Factors affecting the implementation of actions**	
	Operation Zone*	**Company Size****
BNSF	1	Large Revenue > $ 20 million
UP	1	Large Revenue > $ 20 million
CSX	1	Medium: Revenue < $ 20 million, but > $ 5 million
CN	2	Medium: Revenue < $ 20 million, but > $ 5 million
NS	1	Medium: Revenue < $ 20 million, but > $ 5 million
KCS	1	Small Revenue < $ 5 million
CP	2	Medium: Revenue < $ 20 million, but > $ 5 million

* Revenue information considered was from 2018. Data was obtained from: For BNSF (BNSF, 2018a), for UP (Union Pacific, 2018a), for CN (Canadian National, 2018c) for CSX (CSX Corporation, 2018), for NS (Norfolk Southern, 2018), for KCS (Kansas City Southern, 2018b) and for CP (Canadian Pacific, 2018).
** 1) American companies operating through any of the U.S. contiguous States and some Canadian Provinces, and; 2) Canadian companies operating through Canada plus any of the U.S. contiguous States.

4.6 Summary

To answer the research questions, the researcher collected information from companies CSR and CDP reports using interpretive content analysis method. Information was collected based on two frameworks, the existing GRI LTSS 2006 and the Freight Rail Framework to measure emissions reduction and capacity increase of Class I Railroad companies. Simple statistics were used in the analysis of information related to the three research questions.

CHAPTER 5. RESULTS

In this chapter, the results Class I Railroads' CSR reports analysis are explained. First, analysis of statistical data is presented based on SASB metrics such as emissions and revenue ton miles per company. Then results for each research questions are presented. For the first question, the GRI framework was used to collect information. For the second, the more detailed Freight Rail Framework was used to collect the data. Finally, for the third research question, a comparison of the data previously obtained, to company size and legislation and government support was carried out.

5.1.1 Companies' Basic Statistics Based on SASB Evaluation Metrics

The SASB rail freight standard contains material indicators specifically for the rail industry. For this analysis indicators related to air emissions were selected from the list of material topics and data related to carloads transported was collected to compare information. GHG emissions information was compared to total carloads transported. Data was collected for the seven companies in years that were available. Scope 1 emissions which refers to GHG emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) is presented in Table 5.1 and Fig. 5.1. Information was collected for every year in which an analysis of a report was carried out. The column "% change" was calculated as the percent increase or decrease of data from 2018 compared to that of 2010. In the case of KCS and BNSF the percent change was calculated between data from the most recent year (2018) compared to the earliest year data that the data was available (2014). The most significant variations are from CN which increased emissions by 26%, BNSF which increased emissions by 11% and CSX which reduced emissions by 10%.

Table 5.1: Class I Railroad Companies Greenhouse Gas Emissions based on SASB Standards

Sustainability Disclosure Topic	**Company**	**2010**	**2012**	**2014**	**2016**	**2018**	**% change**
Gross Global Scope 1 Emissions (Metric tons CO2-e)	KCS	-	1,285,572	1,399,936	1,374,392	1,400,000	9%
	CP	3,251,161	3,495,877	3,193,530	2,797,461	3,052,104	-6%
	CSX	5,214,546	5,268,905	5,512,604	4,774,800	4,706,707	-10%
	NS	4,958,921	4,925,238	5,358,750	4,927,038	4,930,130	-1%
	CN	4,584,604	5,070,123	5,665,910	5,064,024	5,776,183	26%
	UP	11,207,344	11,595,509	12,277,484	10,295,104	11,279,681	1%
	BNSF	-	14,093,352	15,309,008	13,873,755	15,642,657	11%

Sources: KCS: for 2012 and 2014 (Kansas City Southern, 2014); for 2016 (Kansas City Southern, 2016); for 2018 (Kansas City Southern, 2018a). CP: for 2009 (Canadian Pacific, 2011a), for 2011 (Canadian Pacific, 2012), for 2014 (Canadian Pacific, 2015), for 2016 (Canadian Pacific, 2017), for 2018 (Canadian Pacific, 2019). CSX: for 2010 (CSX Corporation, 2011), for 2012 (CSX Corporation, 2013), for 2014 (CSX Corporation, 2015), for 2016 (CSX Corporation, 2017), for 2018 (CSX Corporation, 2019). NS: for 2010 (Norfolk Southern, 2011b), for 2012 (Norfolk Southern, 2013b), for 2014 (Norfolk Southern, 2015a), for 2016 (Norfolk Southern, 2017a), for 2018 (Norfolk Southern, 2019b). CN: for 2010 (Canadian National, 2011), for 2012 (Canadian National, 2013), for 2014 (Canadian Pacific, 2015), for 2016 (Canadian National, 2017), for 2018 (Canadian National, 2019). UP: for 2010 (Union Pacific, 2011), for 2012 (Union Pacific, 2013), for 2014 (Union Pacific, 2015), for 2016 (Union Pacific, 2017), for 2018 (Union Pacific, 2019). BNSF: for 2012 and 2014 (BNSF, 2015), for 2016 (BNSF, 2017), for 2018 (BNSF, 2018b).
Data for total fuel consumed was converted to Gigajoules from Megawatt hours based on the conversion 1 MWh = 3.60 GJ.

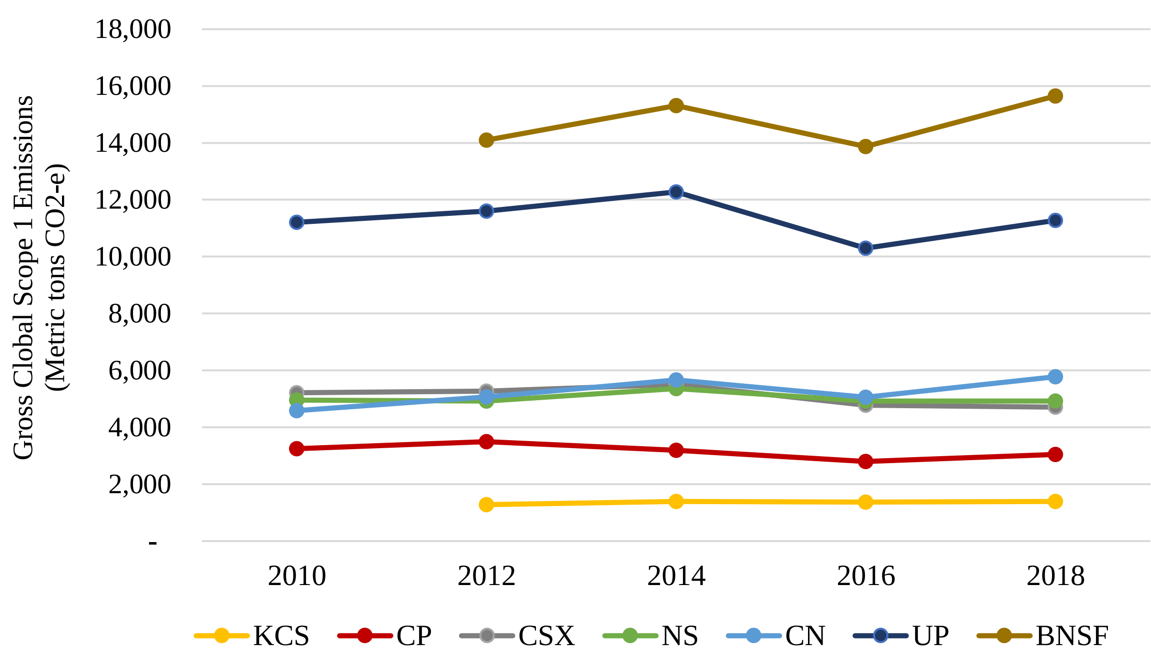

Figure 5.1. Emissions and fuel Consumption by Class I Railroads

Similarly, carloads and intermodal units data transported for the selected years is presented in Table 5.2 and Fig. 5.2. Companies that increased total carloads transported were CN, NS and KCS while UP and BNSF mostly maintained their carloads transported at the same level.

Table 5.2: Class I Railroads, Activity Metrics as per SASB Standards

Activity Metrics	Company	2010	2012	2014	2016	2018	% change
Number of Carloads & Intermodal units Transported (Number)	KCS	-	2,112,100	2,274,100	2,166,900	2,305,600	9%
	CP	2,661,000	2,669,000	2,682,000	2,525,000	2,739,900	3%
	CSX	6,384,000	6,468,000	6,932,000	6,448,000	6,487,000	2%
	NS	6,764,100	7,107,200	7,674,900	7,259,700	7,928,300	17%
	CN	4,683,049	5,039,279	5,696,776	5,192,463	5,956,218	27%
	UP	8,800,676	9,016,116	9,744,489	8,421,799	8,885,963	1%
	BNSF	-	9,661,000	10,275,000	9,758,000	10,698,000	11%

Sources: KCS: for 2012 (Kansas City Southern, 2013), for 2014 (Kansas City Southern, 2014), for 2016 (Kansas City Southern, 2016), for 2018 (Kansas City Southern, 2018a). CP: for 2009 (Canadian Pacific, 2011b), for 2011 (Canadian Pacific, 2013), for 2014, 2016 & 2018 (Canadian Pacific, 2018). CSX: for 2010 (CSX Corporation, 2010), for 2012 (CSX Corporation, 2012), for 2014 (CSX Corporation, 2014), for 2016 (CSX Corporation, 2016), for 2018 (CSX Corporation, 2018). NS: for 2010 (Norfolk Southern, 2010), for 2012 (Norfolk Southern, 2012), for 2014 (Norfolk Southern, 2014), for 2016 (Norfolk Southern, 2016), for 2018 (Norfolk Southern, 2018). CN: for 2010 (Canadian National, 2010b), for 2012 (Canadian National, 2012a), for 2014 (Canadian National, 2014a), for 2016 (Canadian National, 2016a), for 2018 (Canadian National, 2018a). UP: for 2010 (Union Pacific, 2010b), for 2012 (Union Pacific, 2012b), for 2014 (Union Pacific, 2014b), for 2016 (Union Pacific, 2016b), for 2018 (Union Pacific, 2018c). BNSF: for 2012 (BNSF, 2012), for 2014 (BNSF, 2014), for 2016 (BNSF, 2016), for 2018 (BNSF, 2018a).

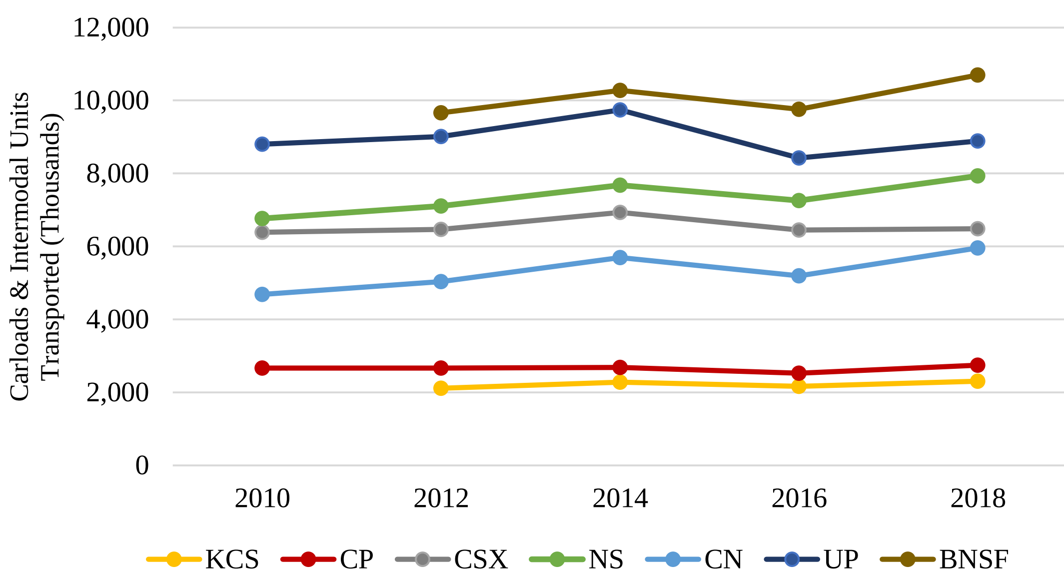

Figure 5.2. Carloads and Intermodal Units Transported Yearly by Class I Railroads

5.1.1.1 Emissions per Carload Transported

To determine emissions during transportation, values of $CO_{2\text{-}e}$ emissions per carload were calculated and are presented in Fig. 5.3 and Table 5.3. Companies which had higher metric tons of $CO_{2\text{-}e}$ per carload transported were BNSF, UP and CP which emitted on average 1.4, 1.26 and 0.98 metric tons of $CO_{2\text{-}e}$ per carload respectively. Companies with the lowest metric tons of $CO_{2\text{-}e}$ per carload transported were KCS, NS and CSX which emitted on average 0.61, 0.68 and 0.77 metric tons of $CO_{2\text{-}e}$ per carload respectively. In regards to how companies' $CO_{2\text{-}e}$ emissions per carload transported changed through the years, each company basically maintained their level of emissions per carload during the 10-year period. Most noticeable differences were the emissions from NS, CSX and CP, which reduced $CO_{2\text{-}e}$ emissions by 15%, 11% and 9% respectively during the 10-year period.

Table 5.3: Class I Railroads, Activity Metrics as per SASB Standards

	Company	**2010**	**2012**	**2014**	**2016**	**2018**	**% change**
Metric tons CO2-e per carload transported	KCS	-	0.61	0.62	0.63	0.61	0%
	CP	1.22	1.31	1.19	1.11	1.11	-9%
	CSX	0.82	0.81	0.80	0.74	0.73	-11%
	NS	0.73	0.69	0.70	0.68	0.62	-15%
	CN	0.98	1.01	0.99	0.98	0.97	-1%
	UP	1.27	1.29	1.26	1.22	1.27	0%
	BNSF	-	1.46	1.49	1.42	1.46	0%

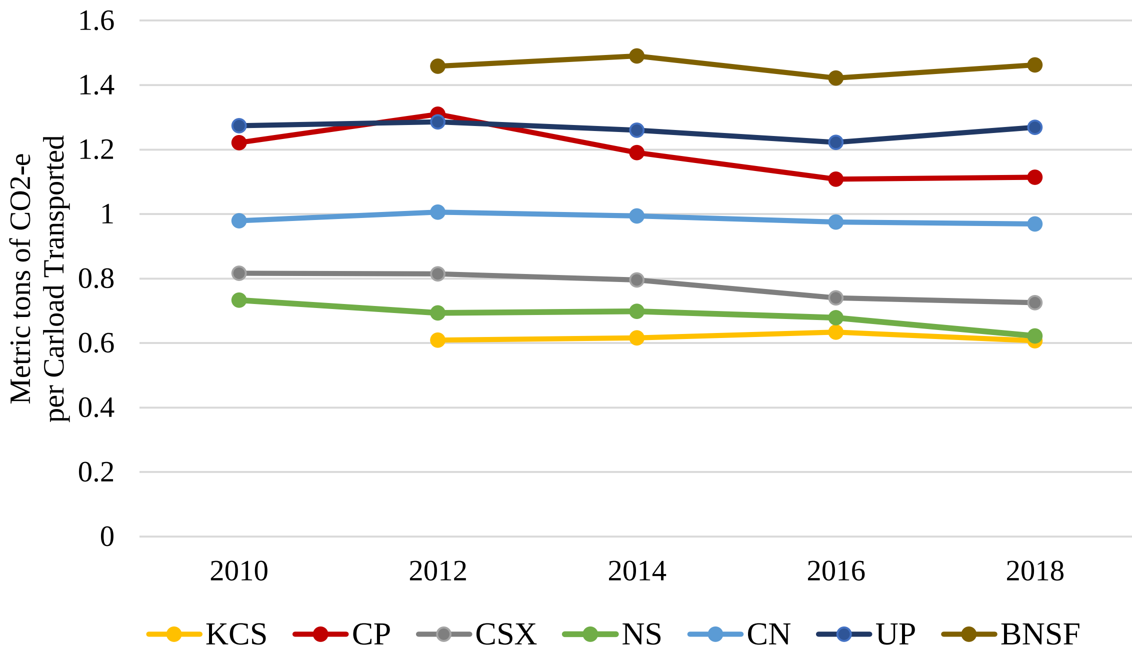

Figure 5.3. $CO_{2\text{-}e}$ Emissions per Carload Transported.

5.2 RQ1: Results of CSR Analysis using the GRI Framework

5.2.1 Empirical Findings

During the period of study, companies published CSR reports 65% of the time. This estimation included the publication of a formal GRI CSR Report or an annual Data Supplement (a shorter version which concentrates the year's most relevant data). Reports' lengths varied from 31 to 129 pages with the average being 68 pages. Reports followed a GRI framework, and companies reported mostly on social indicators. An average of 23, 10 and 5 pages, were used by companies to report social, environmental and economic indicators respectively. The apparent higher importance given to social aspects could related to the number of indicators listed in the GRI LTSS, 2006. The number of indicators by theme were distributed in: 29 social, 17 environmental, and 7 economic indicators (GRI, 2006).

5.2.2 Overall Reporting

In figure 5.4, an overview of the indicators reported during the 10-year period by the seven companies has been presented. Indicators were considered by group (environmental, social and economic indicators). The X axis represents the three groups of indicators, and the Y axis represents the percentage of indicators adopted out of the total number considered from the GRI LTSS, 2006 framework. On average, it was environmental indicators that companies reported mostly on (70%), followed by social (56%) and then economic (44%) indicators.

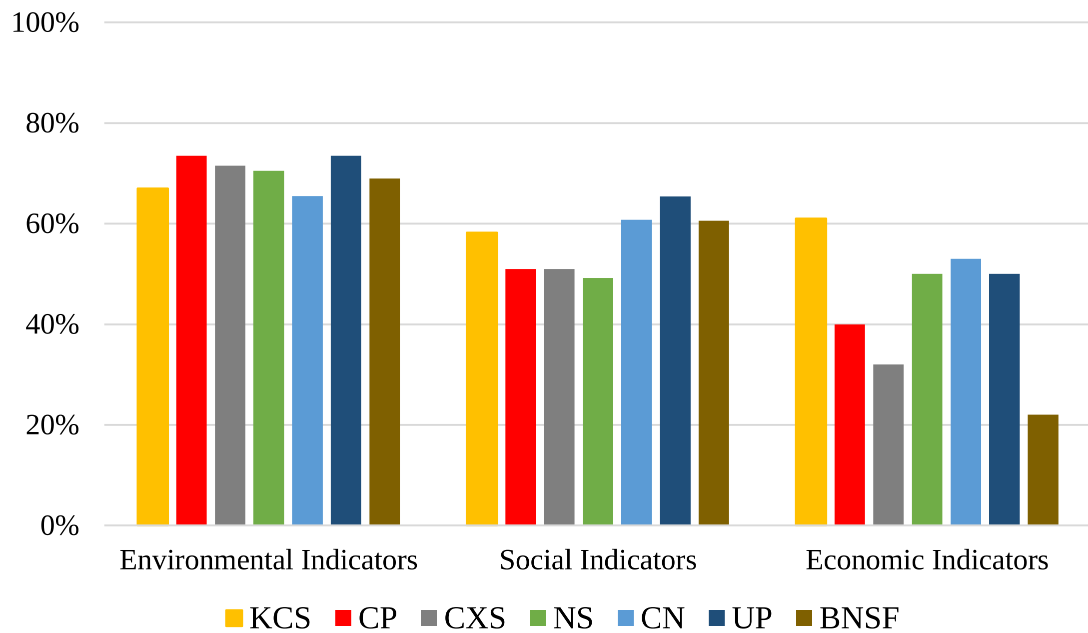

Figure 5.4.Percentage Indicators Reported by Companies Using the GRI Framework

In Figure 5.5 the percentage of indicators companies reported during the 10 years grouped by topic is represented. The first two groups represent the environmental indicators, followed by the five groups of social indicators and the last group represents the economic indicators. Economic aspects were not considered in the more detailed analysis following as their reporting was found to be inconsistent through the years. Additionally, they were not considered critical aspects that needs to be addressed. According to the definition of sustainable transport environmental and safety issues were mentioned as being more critical to be addressed.

Companies reported most consistently on social indicators related to “Labor Practices and Decent Work”, with 95% of the indicators reported on during the past 10 years. Two groups of environmental indicators followed, “Environmental Indicators”, and “Environmental Indicators for the L & T Sector" which had a 75% and 66% of the indicators reported on respectively during the 10-year period.

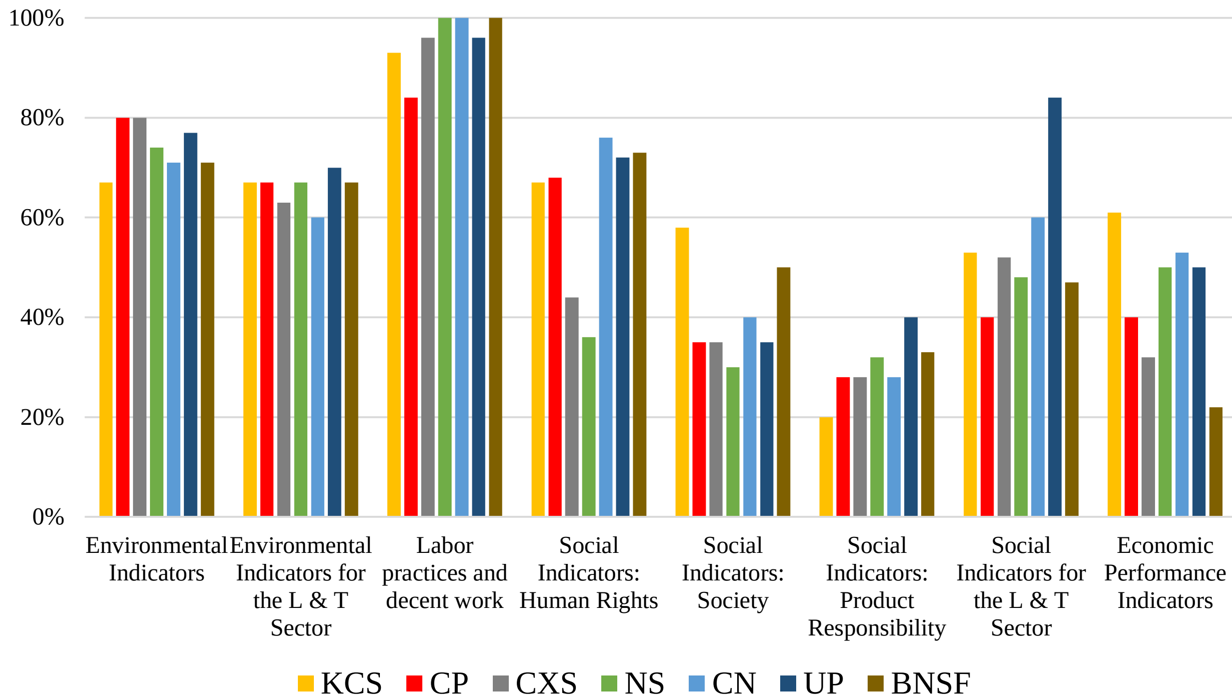

Figure 5.5. Percentage Indicators by Group Using the GRI Framework

The analysis of specific indicators reported by companies was compared to topics listed as part of the "Train Transportation Sustainability Accounting Standard" from SASB. Tables 5.4 and 5.5 represent the average reporting of the six companies for specific environmental and social indicators during the 10-year study period. Only indicators which companies reported more than 80% and less than 20% of the time were included in these lists (Other studies consider companies reported consistently when they reported on more than 75% of the indicators, See Lambrechts et. all, 2019). Indicators that were also part of the SASB standards were highlighted. From the indicators considered in this study (38, refer to Appendix 3), Class I Railroads agreed on the reporting on 23 of the indicators. In 16 of those, companies reported more than 80% of the time, and in seven, companies reported less than 20% of the time.

5.2.3 Environmental Indicators

Environmental indicators reported by companies were mostly related to energy consumption, and to company programs to reduce energy consumption (See Table 5.4). The seven railroads reported consistently on “energy” and on “emissions of effluents and waste”, which refered to the fuel consumed and to the emissions of GHGs and other gases respectively. Both indicators obtained AIs of 94%. The other two indicators companies reported highly on were “energy” and “policy”. Energy referred to the use of energy from renewable sources and to increased energy efficiency, examples included testing of natural gas locomotives, and partnerships with companies to develop locomotives that will support fuel blends. Policy referred to the management of environmental impacts, examples mentioned included installation of idling reduction technology in locomotives and operating longer trains or double staking to reduce energy consumption. Other indicators Railroads reported highly, were “transport infrastructure development”, which referred to impacts from major infrastructure assets (GRI, 2006).

There were two environmental indicators that companies consistently reported low on: “fleet compositions” and “noise /vibration” which companies reported on average 18% and 11% of the time respectively. In relation to environmental indicators considered in the SASB standards: emissions effluents and waste, energy use by source, and energy (includes two of GRI’s indicators: initiatives to use renewable sources and policy), companies reported consistently on the three indicators.

Table 5.4: List of Specific Environmental Indicators

Group of Indicators	Companies' Reporting
Environmental Indicators	
Energy consumed segmented by source*	94%
Emissions (GHG and other indirect GHG emissions)*	94%
Energy (Initiatives to use energy from renewable sources)*	100%
Policies and programs on management of environmental impacts	94%
Urban Air Pollution	90%
Biodiversity	81%
Fleet Compositions	16%
Noise / Vibration	11%

*Indicators included in the SASB Rail Standards.

5.2.4 Social Indicators

Social indicators Railroads considered material were related with employees' benefits, safety and humanitarian programs (See Table 5.5). Indicators related to employees' benefits were the "Labor practices and decent work" group, which included indicators related to companies' total workforce and benefits, percent of employees represented by trade unions and equal opportunity programs. Indicators in this group companies reported between 94% and 100% of the time. These indicators were similar in most companies listing the total number of employees and number of employees organized in different labor unions. Training and education referred mostly to training in safety programs but also in locomotives' management to reduce energy consumption. Diversity and opportunity programs mostly referred to promoting women in all positions as the percentage of women employees in the rail industry had always been lower compared to men.

Safety was another topic that was given great importance by railroads. Companies reported on these between 90% and 100% of the time. Safety indicators included: employee' "health and safety", "road safety", "safety training and education" and "customer health and safety". Statistics reported on consistently were the numbers of accidents & injuries, numbers of fatalities, of employees and third parties. Also, railroads reported consistently on several of their safety strategies: 1) Employees' training programs to promote safety in the workplace and training in locomotive software. 2) Software upgrades installed in locomotives and the rail network to avoid accidents such as "Positive train control" (PTC). 3) Education programs for communities living in close proximity to railroads to avoid accidents. The reporting of social aspects related to community support which refer to "community" and "humanitarian programs" were also material for the rail industry. Companies reported consistently in both indicators 100% of the time. The type of projects reported refer to food distribution, several types of volunteering from employees and financial help to different community programs.

In regards to other groups of indicators, the "human rights" group had also high percentages of reporting (61% average). "Non-discrimination policies" had the highest AI, (87%), and the "social performance indicators for the logistics and transportation sector" group had a similar average of reporting (55%). In this group, however, the reporting of most indicators was low (29% to 39%), except for "road safety" and "humanitarian programs". Finally, the "product responsibility" group had the lowest average reporting 30%. All indicators in this group had AIs of 6% to 32%, except for "customer health and safety". Specific social indicators which companies reported were the lowest part of "product responsibility" and the "society" group: "competition and pricing", "advertising", "respect for privacy" and "mobile working patterns" with averages reporting between 3% and 19% (See Table 5.5).

Social indicators part of the SASB standards were related to safety and competition and pricing. There were three safety indicators from SASB which record: incident rates, fatality rates and near miss frequency rates. Railroads constantly reported on the first two indicators, but near miss frequency rates were not clearly identified in the analyzed reports. Finally, competition and pricing was not consistently reported by companies.

Table 5.5: List of Specific Social Indicators

Group of Indicators	Companies' Reporting
Social Indicators	
Employees' health and safety (occupational health and accidents) *	100%
Road safety *	94%
Employment (workforce, average turnover, employee benefits)	94%
Labor/ Management Relations (Percent employees represented by trade union organizations)	94%
Training and Education (Transport and safety training)	94%
Diversity and Opportunity (Equal opportunity programs)	97%
Community (Management of impacts to communities)	100%
Customer health and safety	90%
Humanitarian Programs (Delivery of humanitarian programs locally and globally)	100%
Competition and Pricing * (Cases related to anti-trust and monopoly regulations, mechanisms for preventing anti-competitive behavior)	3%
Advertising (mechanisms for adherence to standards and voluntary advertising codes)	6%
Respect for Privacy (mechanisms for consumer privacy, number of breaches)	16%
Mobile Worker Working Patterns (programs to determine working / rest hours)	6%
Substance Abuse	19%

*Indicators included in the SASB Rail Standards.

5.3 RQ2: Results of Indicators to Reduce Air Emissions and Increase Capacity

5.3.1 Freight Rail Framework Development

The framework was developed to identify in more detail which types of practices were being incorporated by companies to reduce emissions while transporting. Also, because indicators addressing this issue in the other frameworks used (GRI, CDP and SASB), lacked the specificity necessary to understand railroads reporting. Questions from existing guidelines collected information related to amounts of energy consumed, and gas emissions (GHGs and other air pollutants) (See GRI, 2006; CDP, 2018b and SASB, 2018). The CDP and SASB questionnaires had only one question addressing strategies to reduce emissions. While, the GRI (2006) did include two questions addressing aspects of strategies, more detail was needed. For example one of the questions from the GRI stated: "*Description of initiatives to use renewable energy sources and to increase energy efficiency*". The answer could have included several strategies such as the use of biofuels, running longer and/or double stacked trains, and improvements to locomotive engines. The Freight Rail Framework (FRF) allowed the researcher to classify each of those strategies in different categories: "use of alternative fuels", "internal operational strategies" and "locomotive technology".

The FRF was based on other studies which offered lists of aspects that freight and/or transport companies could tackle to become more environmentally friendly (See classifications by Colicchia et al., 2013 and Smokers et al., 2014). It was also based on concepts identified as important to be addressed by the rail freight industry to become more environmentally friendly. The first was reducing fossil fuel share (Helmreich & Keller, 2011); and the second was increasing capacity. Rail transportation was considered one of the least polluting modes available for freight travel, and increasing the use of rail over other more polluting modes was seen as key to reduce the air emissions of the entire freight system (Bitzan & Keeler, 2011). Table 3.4 includes a list of the different practices railroads could improve as were identified in the literature review. .

The FRF was therefore developed to incorporate a holistic view of rail. First as part of a system where its advantage is that it pollutes than other modes, and, second, as a transport mode that needed to continue to reduce its environmental impact. Indicators from the FRF were divided into two groups: operational, and technological strategies.

Operational strategies referred to changes to the operations of a company that could help improve the efficiency and improve intermodal transport. Changes considered were related to reorganizing the assets a company already owns, hence investments required were considered to be low. There were two groups of operational strategies: 1) “External operational strategies” which referred to a company’s cooperation with external companies such as: with other transport carriers, with customers or with government institutions; and 2) Internal operational strategies which referred to improvements such as operating longer and/or double stalked trains, educating driver engineers, locomotives’ maintenance and lubrication.

Technological and infrastructure strategies dealt more directly with the reduction of air emissions, and for the most part required a heavier investment from companies. Technological strategies were divided in three groups: 1) “Locomotive technology” which included, improvements to locomotives’ engines, the replacement of older locomotives with newer less polluting ones and the installation of software for more efficient operations. 2) “Use of alternative fuels” included biofuels and other fuels. From a variety of alternative fuels mentioned in the literature, biofuels was the most common option however, testing with hydrogen fuel, natural gas and electric locomotives was also mentioned. 3) “Infrastructure development”, referred to upgrades in the rail network and construction of new railroads or new railyards. Infrastructure development in many cases required high investment and improvements were directed at reducing emissions from improved operations and capacity increase.

Because more detail was required from this framework, and the coding system of four levels (0 – 3) was selected, the FRF was designed so that each indicator could include at least three projects. For example for the indicator “Train area marshaling” several projects could have been implemented, such as: operating longer trains, double stalked trains, ensuring the same gap-distance between cars to reduce wind resistance and distributing locomotives amongst trains to reduce energy consumption. Also, in the indicator technology, there were different aspects companies could invest on such as: research, purchasing new locomotives and upgrading the engine of an existing one. Finally, to ensure validity of the FRF, the researcher confirmed each indicator was mentioned at least twice in the literature. The FRF is presented in Appendix 3.

5.3.2 Empirical Findings

Information from both companies CSR and CDP reports was collected to answer the second research question. In addition to their CSR reports, companies reported 74% of the time to the CDP climate change questionnaire. Because not all companies reported to the CDP, the reporting of five of the seven Class I Railroads was analyzed. A Quality Index (QI) was calculated based on the values assigned to the information related to each indicator. Values assigned to the data collected were from 0 to 3. The "0" value was assigned when there was no mention of the indicator and values 1-3 were assigned based on the number of projects implemented for a specific indicator. A summary of the major aspects that each company is reporting on has been included in Appendix 6.

5.3.3 Overall Reporting

In Fig. 5.6, the average QI for the reporting of the five companies (CP, CSX, NS, CN and UP) during the period of study is presented. The results were divided by category into operational and technological indicators. The X axis represents the specific indicator, and the Y axis the QI with the highest value being three. There was little difference found on the reporting of the two groups of indicators.

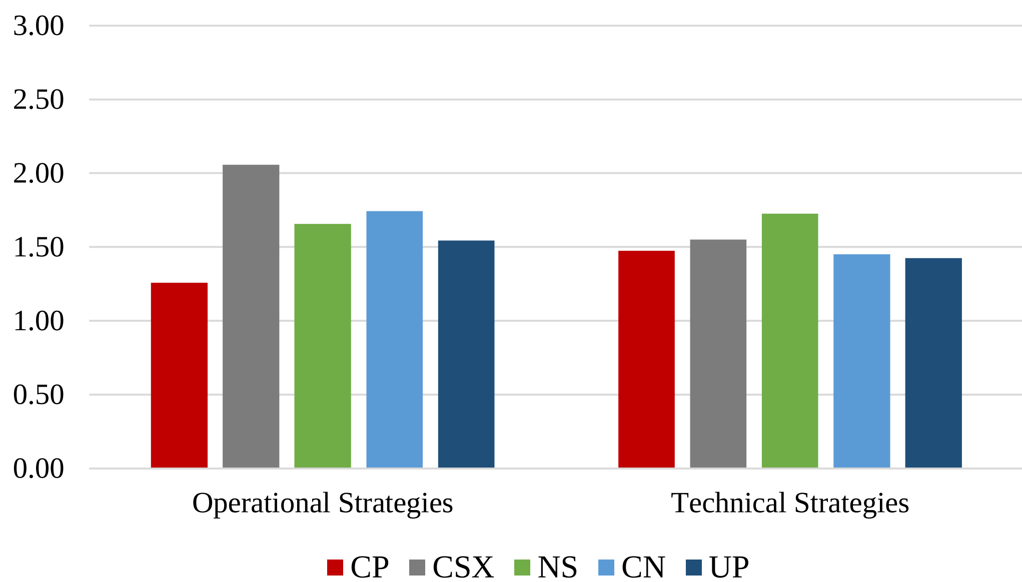

Figure 5.6. Quality Index of Indicators Based on the Freight Rail Framework.

In Fig. 5.7, the reporting of the five subgroups of indicators within each category (Internal and External Operational Strategies and Locomotive Technology, the Use of Alternative Fuels and Infrastructure) is represented. Differences in the reporting became more evident when comparing subgroups of indicators. Indicators companies were relying most were "Locomotive Technology", "External Operational Strategies" and "Infrastructure" with QI's of 1.97, 1.76 and 1.60 respectively. The group of indicators companies considered the least were the "Use of alternative fuels" which had an overall QI of 0.74 for the years studied.

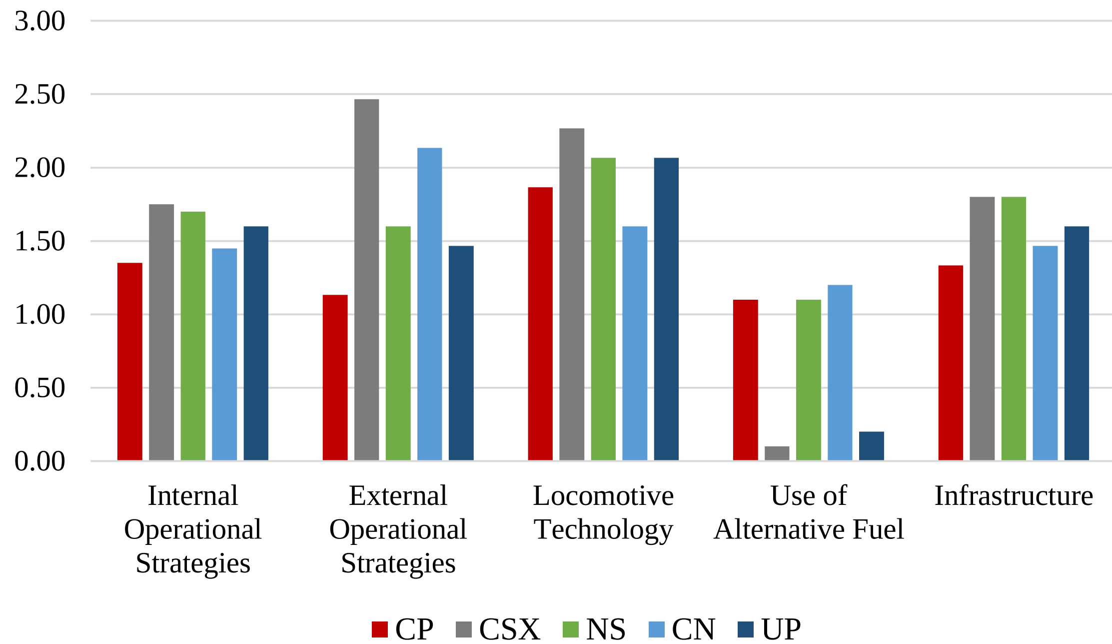

Figure 5.7. Quality Index of Indicators by Sub-groups Based on the Freight Rail Framework.

5.3.4 Operational Strategies

The reporting of external and internal Operational Strategies (OS) for each company during the 10 year period is shown in Figs. 5.8 and 5.9 respectively. The X axis represents the five different years and the Y axis the Quality Index (QI). The dotted line represents each company's reporting trend. The average QI of all companies of external OS was 1.77, which was the highest AI after "locomotive technology" from technological strategies. There were two patterns identified: 1) Reporting of External and Internal OS is irregular, their coefficient of variation is 32% and 26% for respectively. Some companies increase their reporting though the years others reduce it. The reporting of External OS, for example, NS and UP, decrease reporting while CP, CSX and CN increase reporting. 2) On average the reporting QI of both groups of indicators decreased slightly over the years. The QI of external OS reduced from 1.87 in 2010 to 1.53 in 2018, and internal OS QI reduced from 1.80 in 2010 to 1.55 in 2018.

External OS railroads mostly reported on “cooperation with private associations/ customers” (i.e., building of railroads to reach a customer sites) and “collaboration with public institutions”. CSX reported the highest in “external operational strategies”; one of the largest projects mentioned was the National Gateway project launched in 2008, a public-private partnership intended to invest in several projects to increase network capacity (CSX, CDP, 2019). Reporting of Internal OS had a QI of 1.58. Most common indicators reported on were railyards and/or railroads operation improvements (i.e., implementing IT systems to speed up truck entry at railyards) and train area marshalling (i.e., operating longer or double stack trains).

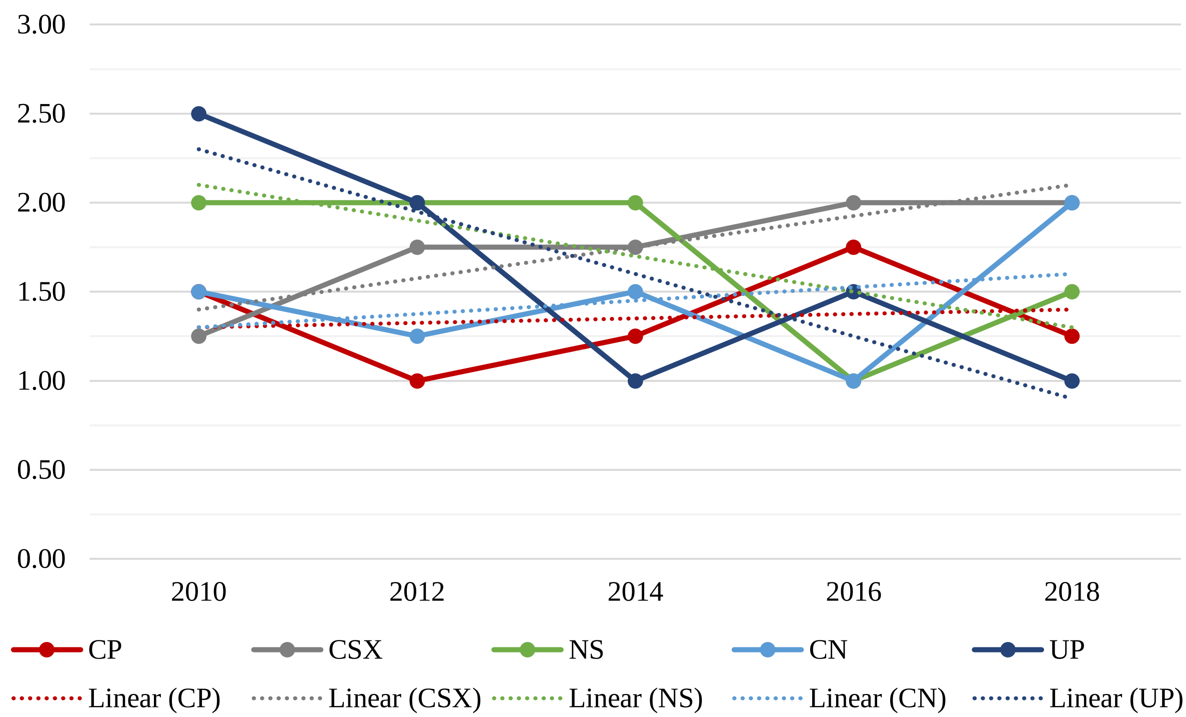

Figure 5.8. Quality Index of Internal Operational Strategies per Company and per Year

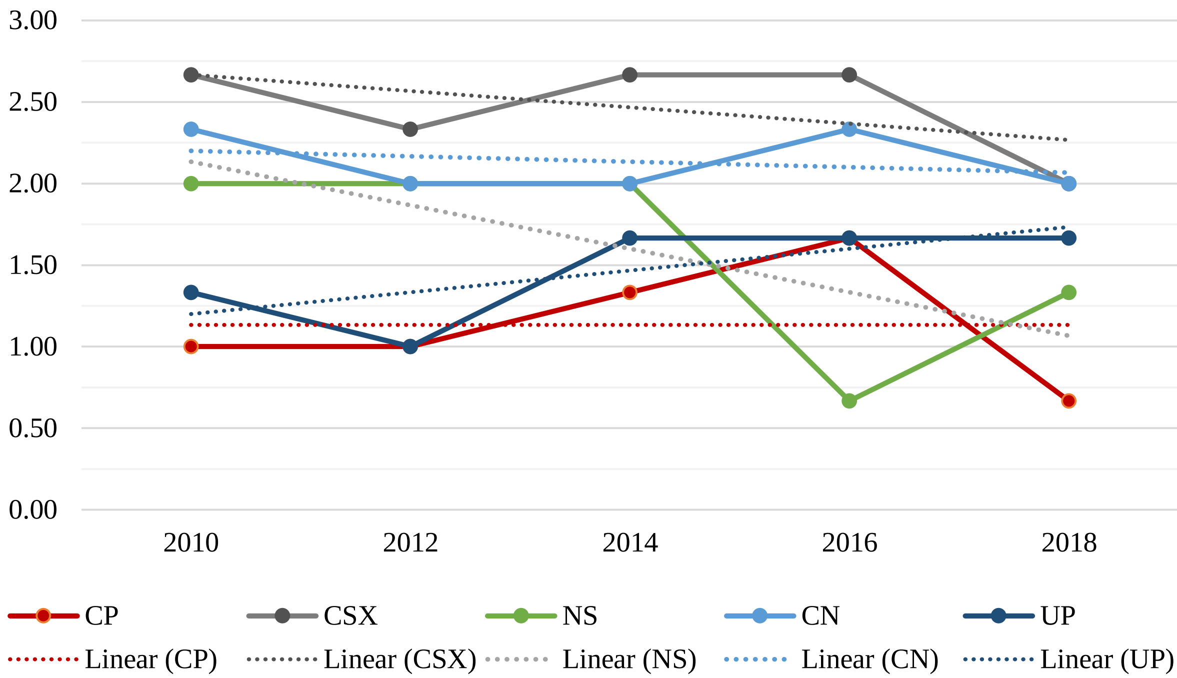

Figure 5.9. Quality Index of External Operational Strategies per Company and per Year

5.3.5 Technological Strategies

The reporting of the three groups part of Technological Strategies are presented in Figs. 5.10 to 5.12. “Locomotive technology” had the highest overall QI at 1.93, followed by “infrastructure” with a QI of 1.60 and “use of alternative fuels” with the lowest QI at 0.82. “Locomotive technology” was mentioned in every report as one of companies’ main investment towards increasing energy efficiency. It was the acquisition of new locomotives and the implementation of software for efficient operations that the indicators railroads relied mostly on. New locomotives included purchase of locomotives to comply with Tier 3&4 standards, but also the work with other institutions in the design and testing of new more efficient technologies. UP in particular invested heavily in the acquisition of new locomotives and in the research of several technologies to reduce emissions (Union Pacific, 2012a).

“Infrastructure investment” was given great importance by CSX, NS and UP. Large infrastructure projects mentioned were public-private investments such as the National Gateway project designed to increase capacity and to create a link between the Mid-West and Mid-Atlantic ports (CSX Corporation, 2010). Other large projects included upgrades to corridors also to increase capacity such as the Alameda corridor by UP (Union Pacific, 2010a) and the Crescent corridor that joins 11 states in the Midwest by NS (Norfolk Southern, 2013a). Smaller projects mentioned by all railroads included upgrades to existing rail lines.

In relation to the "use of alternative fuels", railroads mostly focused in the testing of different types of fuels (i.e., vegetable blend biodiesel, electric engines and hydrogen fuel cells). Although, several testing projects seemed not to have been successful, there was a slight increase on the use of alternative fuels. From the five companies analyzed, only CP, CN and NS mention the use of alternative fuels as one of the main strategies used to increase energy efficiency.

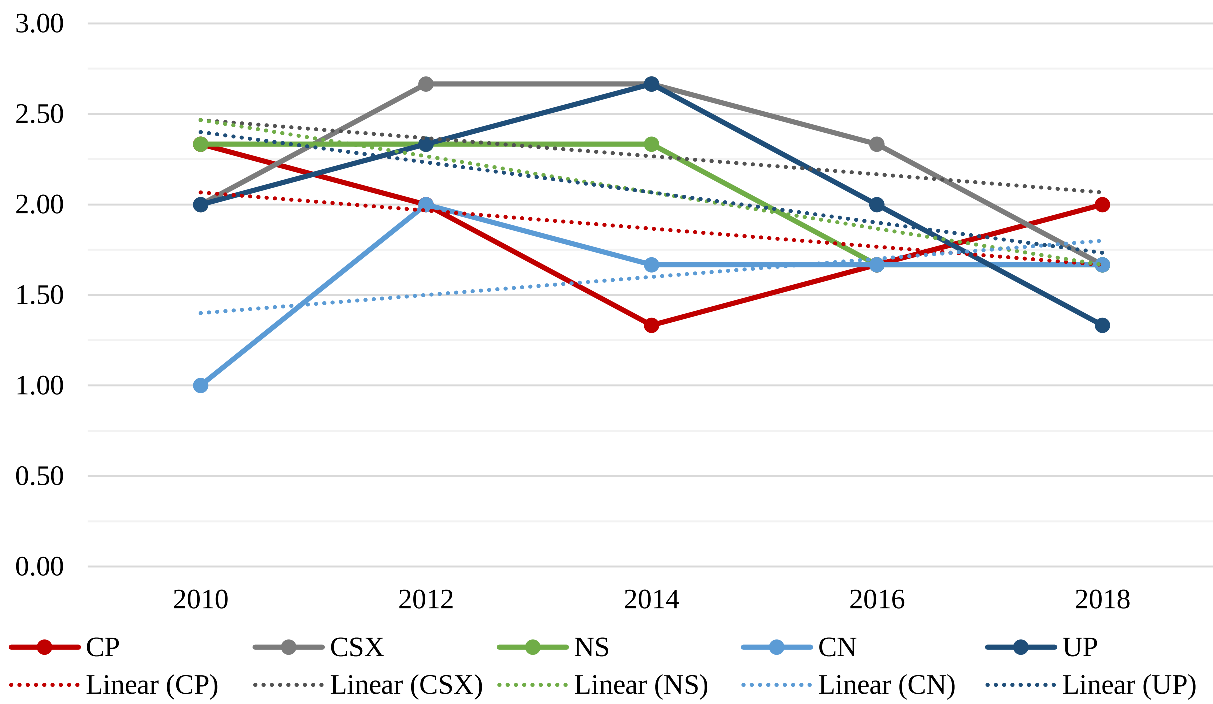

Figure 5.10. Quality Index Reporting of Locomotive Technology Indicators

There was a difference noted in the reporting of technological strategies between American vs. Canadian companies. CSX, NS and UP overall decreased the quality of their reporting though the years while Canadian companies mostly maintained their level of reporting. The reporting of "locomotive technology" (Fig. 5.10) showed that the three American companies reduced the number of indicators reported on after 2014 and they also reduced the overall QI reported from 2010 to 2018 from an average of 2.11 to 1.56. From the Canadian companies instead, although on average their QI is lower than the average QI for the American companies, CN increased and lowered but only from 2.33 to 2.00 their reporting of locomotive technology in the ten-year period. Although the reporting of all companies reduced though the years, this is the group of indicators with the smallest variance at (20%) among all the groups. This combined with the fact that the group has the highest QI amongst all groups of indicators shows the importance given to locomotive technology by railroads.

A similar pattern is shown in Fig. 5.11, which has represented the reporting of the use of Alternative Fuels. The reporting by NS had the biggest change though the years. In 2010 and 2012, NS was reporting on the highest number of projects aiming to increase the use of alternative fuels. Projects included testing of synthetic diesel from animal fat, vegetable-based biodiesel, electric engines and hydrogen fuel cells (Norfolk Southern, 2013a). However in 2016, their reporting on the subject dropped to almost zero. By 2018, the three American companies reported a low QI (between zero and 0.5). CP and CN instead maintained a similar level of reporting though the years (between 1.00 and 1.50). Also, the reporting of the use of alternative fuels was the least consistent amongst all the groups of indicators, it had the largest coefficient of variation at (86%).

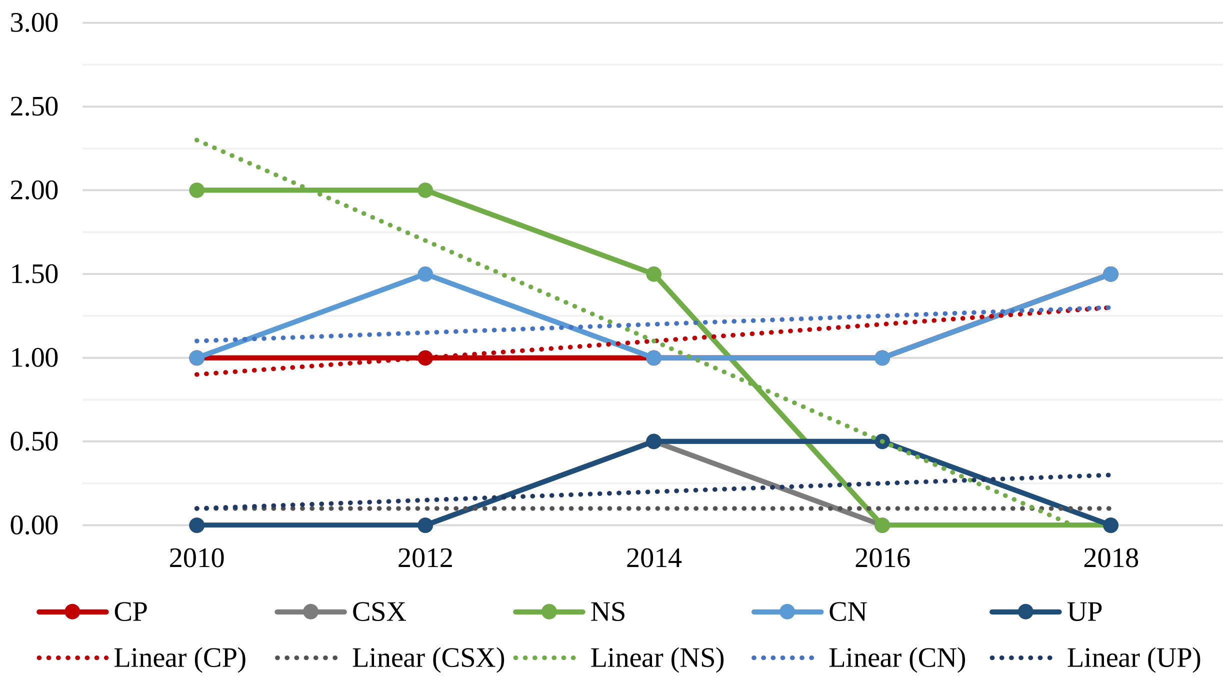

Figure 5.11. Quality Index Reporting of Alternative Fuels Indicators

Finally, the reporting of infrastructure indicators is shown in Fig. 5.12. American companies lowered their QI between 2012 and 2014, while Canadian companies increased their QI between 2014 and 2016. The three American companies reported a high QI at the start of the period (between 2 and 2.30 in 2010), that dropped to between 0.70 and 1.30 by 2018. CP and CN instead started with lower QIs (1.30 in 2010), but that increased though the years and ended at 2.00 and 1.20 for CP and CN respectively in 2018.

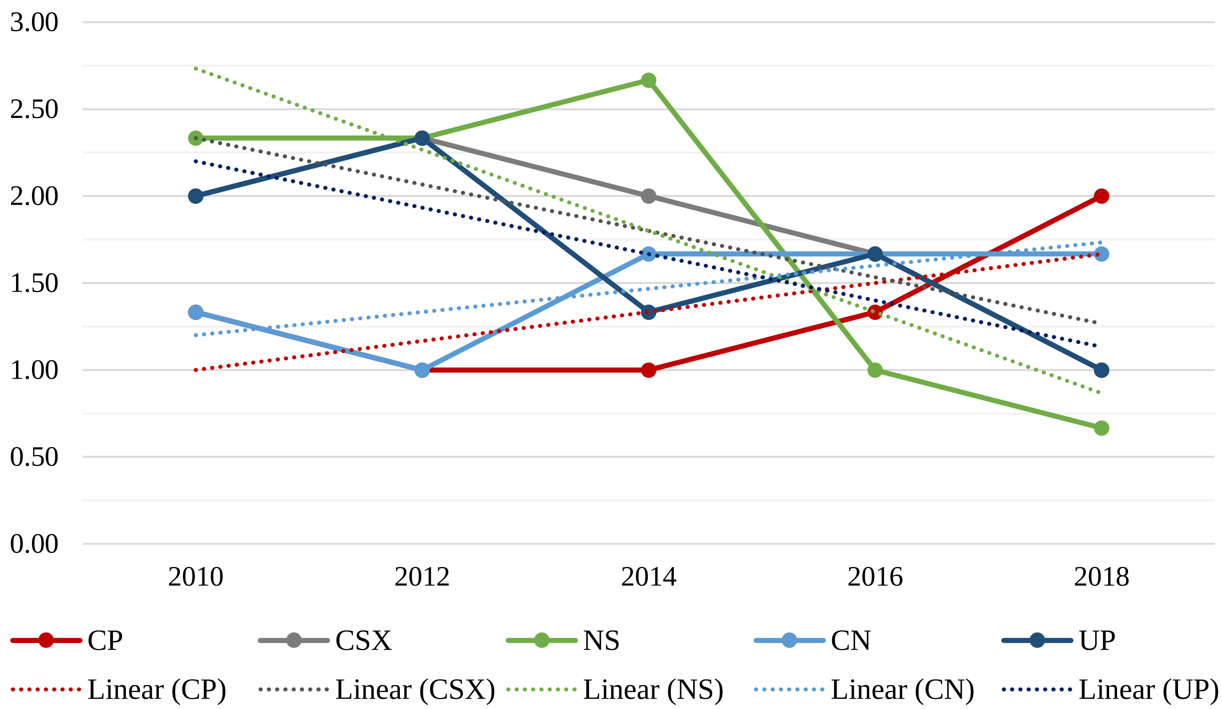

Figure 5.12. Quality Index Reporting of Infrastructure Indicators

5.4 RQ3: Results for Factors Influencing the Number of Indicators Being Implemented by Class I Railroad Companies to Reduce Air Emissions

Factors that might be influencing the level and quality of reporting considered in this study were those of company size and environmental legislation applicable to the geographical area where Class I Railroad companies operate.

5.4.1 Company Size

As in previous studies, company size was measured based on annual revenue and average number of employees. In Fig. 5.13, the company size of the seven Class 1 railroads are presented based on their annual revenue in 2018. KCS was the smallest company with a revenue of 2,71 million USD while BNSF was the largest with an annual revenue of 23,85 million USD.

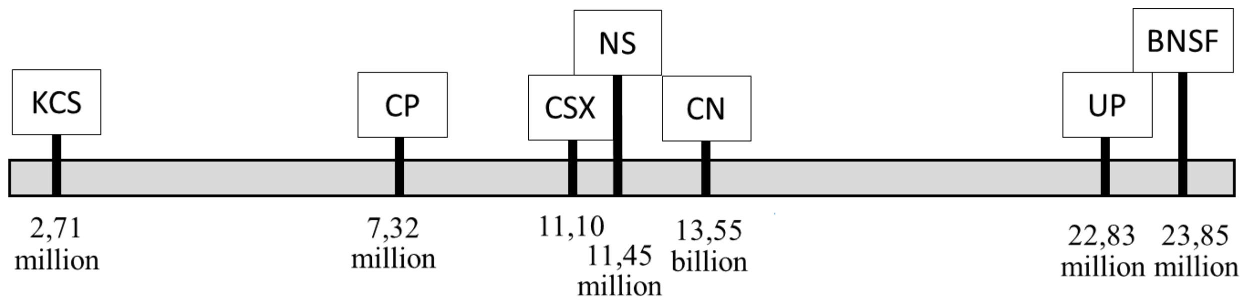

Figure 5.13. Company Size by 2018 Total Revenue

Table 5.6 contains the average reporting during the ten years of Adoption Index (AI) and Quality Index (QI) values calculated in the previous sections. Companies were organized from the smallest at the left (KCS) to the largest (BNSF) at the right. The dark grey number refers to the highest value of each row.

Differences on the reporting based on company size were not evident. Although results of reporting to the GRI framework did indicate larger companies were reporting more than the smaller ones, there was overall little variability between their reporting. Also, the results of reporting between the GRI and FRF were different. For the FRF, it was medium-sized companies which reported the highest. In relation to the reporting to the GRI, UP, the second largest company reported on the highest number of environmental and social indicators (average of 69%). The other two companies that reported a high number of indicators were CN and BNSF, considered medium and large-sized companies. The lowest overall reporting was by NS, a medium-sized company which reported an average AI of 58%.

When comparing the overall Quality Index of the FRF, similar to the GRI results, the differences between the highest and lowest reporting companies were small. In this case, NS and CSX reported the highest overall QI (1.75 and 1.73 respectively). CSX reported the highest QI in

Operational Strategies while NS reported the highest QI of Technological Strategies. KCS, the smallest company reported the lowest overall QI (1.40) and the lowest QI of Operational Strategies (1.31). CP, CN and UP, medium and large companies, reported the lowest QI of technological strategies (1.45).

Table 5.6: Summary of Reporting Characteristics

GRI Framework							
Group of Indicators	**KCS**	**CP**	**CSX**	**NS**	**CN**	**UP**	**BNSF**
Environmental Performance	67%	80%	77%	74%	71%	77%	71%
New Environmental Performance for the L&T Sector	67%	67%	63%	67%	60%	70%	67%
Total Environmental Indicators	67%	74%	72%	71%	66%	74%	69%
Labor practices and decent work	93%	84%	96%	100%	100%	96%	100%
Human Rights	67%	68%	44%	36%	76%	72%	73%
Society	58%	25%	35%	30%	40%	35%	50%
Product Responsibility	20%	28%	28%	32%	28%	40%	33%
New Social Performance Indicators for the L & T Sector	53%	40%	52%	48%	60%	84%	47%
Total Social Indicators	57%	50%	52%	49%	62%	63%	61%
Overall Adoption Index	60%	58%	58%	57%	63%	67%	64%
Freight Rail Framework							
External Operational Strategies	-	1.20	2.40	1.60	2.13	1.47	-
Internal Operational Strategies	-	1.40	1.75	1.70	1.45	1.60	-
Total Operational Strategies	-	1.31	2.06	1.66	1.74	1.54	-
Locomotive Technology	-	1.45	2.07	2.07	1.67	2.07	-
Alternative Fuels use	-	1.10	0.10	1.50	1.20	0.20	-
Infrastructure	-	1.27	1.80	1.80	1.47	1.67	-
Total Technological Strategies	-	1.45	1.48	1.83	1.45	1.45	-
Overall Quality Index	-	1.39	1.73	1.75	1.59	1.49	-

Although it was not evident company size influenced the reporting of Class I Railroads, some of the strategies used to reduce emissions did vary between large and the small companies. Larger investments are made by the larger companies. KCS and CP for example, the smaller companies, did not rely as much in the purchase of new locomotives to reduce their emissions, neither did they mention large investments in research of new locomotive technology. KCS mostly mentioned the use of software such as trip optimizer and management strategies such as distributive power and reducing idling as ways to reduce emissions (Kansas City Southern, 2016, 2018a). CP, mostly relied in retrofitting of electric-diesel locomotives and the use and testing of alternative fuels as mechanisms to reduce emissions (Canadian Pacific, 2014). UP instead, mentioned the purchase of at least 100 new locomotives in its CSR reports between 2010 and 2016 (Union Pacific, 2012a, 2016a). In 2018 the company only purchased 51 new locomotives (Union Pacific, 2018b). UP also invested heavily in the development and testing of the Genset Switcher locomotive (Union Pacific, 2012a).

5.4.2 Legislation and Government Support

The effect of the legislation and government support was analyzed based on Railroads location, in two groups: American and Canadian companies. In addition to verifying differences in the reporting of specific years, changes in the reporting through the years were also analyzed. Because of legislation and support were directed at technological aspects, the three groups of technological indicators from the FRF were compared to the application of legislation and government support as per Fig. 5.14. Overall, there was an indication that government policies and support did influence companies' reporting.

- Locomotive Technology → Emissions Standards (EPA) & Canadian MoU
- Infrastructure → Government Grants
- Use of Alternative Fuels → Emission Standards (EPA) & Canadian MoU

Figure 5.14. Comparison between Technological Indicators and Legislation/Government Support

Legislation considered, were policies to control emissions caused during transportation. Regulations that came into place before and during the period of study and that could have affected company reporting were summarized below:

- 2000 EPA's Tier 0, 1 and 2 Locomotive emission standards.
- 2008 EPA's Shut down technology policy.
- 2015 EPA's Tier 3 and 4 Locomotive emission standards. Adopted in 2011/2012 and became effective since 2015.

- 2011-2017 Canadian Memorandum of Understanding (MoU) signed between Transportation Canada and the Railway Association of Canada. Encouraged Canadian Rail companies to reduce 6% of GHG emissions and limited emissions of Criteria Air Contaminants.
- 2018 Canadian MoU signed between Transportation Canada and the Railway Association of Canada. Encouraged Canadian Rail companies to reduce 6% of GHG emissions and limited emissions of Criteria Air Contaminants.

A summary of the regulations affecting Class I Railroads divided by operation zone is shown in Table 5.7. USA policies were applicable from the start date onwards, while Canadian MoUs were applied to specific years. Policies were applicable to companies depending upon their operation zone i.e., CN had to comply with USA and Canadian Policies as the company runs through US States and Canadian Provinces.

Table 5.7: Summary of Legislation

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
USA	**2000** Tier 1 & 2 Locomotive Standards Limits to CAP*											
	2008 Shut down technology policy											
							2015 Tier 3-4 Locomotive Standards Limits to CAP*					
CANADA	**2006-2010** 2nd Memorandum Limits to CAC* 6% Reduction of GHG emissions		**2011 - 2017** 3rd Memorandum Limits to CAC** 6% Reduction of GHG emissions							**2018-2022** 4th Memorandum Limits to CAC** 6% Reduction of GHG emissions		

*Criteria air pollutants regulated by the EPA: Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx) and Particulate Matter ($PM_{2.5\ \&\ 10}$).
**Criteria Air Contaminants regulated by Transport Canada: Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx), Particulate Matter (PM) and Sulfur Oxides (SO_2).

Government support considered were government grants and support to invest in infrastructure and in alternative fuels testing, it included:

- U.S. Tiger grants offered to American companies since 2008 which encouraged investment in infrastructure.

- Funding by the Canadian government to invest in rail technologies. One of the main projects mentioned was the development of renewable diesel from lignin (Delphi & Delphi, 2019).

Results showed firstly that, overall, the FRF's reporting decreased through the years. Average overall reporting in 2010 for all indicators was 1.68. While reporting was maintained in 2012 and 2014 with QIs of 1.70 and 1.67 respectively, the QIs decreased in 2016 and 2018 to 1.49 and 1.40 respectively. One of the major changes in the overall policies was the US decision to withdraw from the Paris agreement in 2017 (U.S. State Dep., 2019). This meant that the US no longer had the commitment to reduce GHG emissions.

Second, there was a change in the reporting of locomotive technology, which differed between Canadian and American companies and that aligned with changes in the legislation (U.S. Emissions Standards and Canadian MoUs). CSX, NS and UP although with higher QIs than the Canadian companies, they decreased their reporting through the years. CP and CN instead maintained and increased their reporting. CSX, NS and UP had a QI in 2010 of 2.00 for CSX and UP and a 2.3 for NS. The average reporting for the three companies reduced in 2016 and it further reduced in 2018. By 2018 the average QI was 1.67 for CSX and NS, and 1.33 for UP. CP and CN instead show a different behavior. While CP also reduced its QI, from 2.33 in 2010 to 2.00 in 2018, the company increased its reporting in 2016 and 2018 compared to 2012 and 2014. CN also increased its overall reporting from 1.00 in 2010 to 1.67 in 2018.

Prior to the application of new standards in 2015, companies were aware that Tier 3 and 4 standards would be enforced in 2015. Reports from before and a few after 2015 showed companies reported on several technologic projects that would help reduce locomotive emissions and comply with the new standards. However, after 2015 there has been no knowledge of new standards or requirements to lower emissions from locomotives coming into effect. This matches the reporting by the three American companies that decreased their reporting in 2016 and 2018 when compared to 2010 to 2014. Canadian companies instead, in addition to locomotive standards had to comply with the third and fourth memorandums of understanding applicable in 2011 and 2018 respectively which had as requirement to decrease emissions of GHGs.

A very similar pattern was found in the reporting of use of "alternative fuels", behavior of American and Canadian companies differed. American companies either maintained a low level of reporting or reduced reporting considerably during the period of study while Canadian companies maintained and increased their reporting of the use of alternative fuels. The most noticeable change was in the reporting of NS. The company reported on different projects related to testing and use of biofuels in its reports from 2010, 2012 and 2014. However in 2016 and 2018 NS only reported the use of biofuel and no testing was mentioned. CSX and UP did not report the use of biofuels during the period of study and mentioned the use of 'other alternative fuels' in one and two years respectively. CP and CN instead reported constantly on the use and/or testing of biofuels and other alternative fuels during the period of study.

The difference of behavior can be associated to the MoU signed between Transport Canada and the two Canadian Railroads. The legislation asked for reduction of GHGs emissions, and as previously stated, emissions of GHGs are directly related to the type of fuel consumed. While emissions of criteria air pollutants are related to locomotive's engines. Regulating GHG emissions should have a direct impact on the type of fuel railroads choose to use, either to only use diesel or increase the use of biodiesel or other types of biofuels. Although Canadian legislation should apply to NS, CSX and UP, as they run though Canadian provinces, companies did not mention their compliance with Canadian MoU in their reports. Also, the 2017 Locomotive Emissions Report from Rail Canada only included achievements of CP and CN (Delphi & Delphi, 2019).

Infrastructure was the last group of technological indicators which had differences in the reporting between American and Canadian Railroads. On average American companies reported higher QI's during the period of study, however, their behavior in reporting was different from that of Canadian companies. American companies were investing heavily in infrastructure at the beginning of the period 2010 and 2012 with QI's between 2.00 and 2.33. However, the number of projects reported dropped in 2014 onwards with averages QIs in 2018 being between 0.67 and 1.00. CP and CN instead maintained and slightly increased their reporting though the period of study. Canadian companies started in 2010 with an average reporting of 1.33 and by 2018 the average QI of infrastructure was 2.00 and 1.67 for CP and CN respectively.

Reporting of American companies could be related to American government investments in the Tiger Grants offered on a yearly basis. In 2010, the government offered $105 million grant to a "multi-state" rail program. This was referenced by CSX, NS and UP when mentioning some of their large infrastructure projects. However, by 2016 and 2018, although the Tiger Grants program continued to be offered by the Department of Transportation, their quantity was considerably lower than grants awarded in 2008 (U.S. DOT, 2020).

Overall, differences in the reporting considering the Legislation and/or government support, were related to the country where the companies belong to: U.S. or Canada. There were no differences found in the reporting by operation zone as they were proposed on table 4.4.

5.5 Summary

The chapter contains results from the report analysis carried out to answer the three research questions plus data of emissions and carloads transported based on SASB metrics. Data was presented using simple statistics. Adoption Index used to answer the first research question was calculated as a percentage of the number of indicators companies reported on. Quality Index, used to analyze data from the second research question. The QI was calculated from codification of information based on the number of projects and the quality of information described. In the third research question, results were compared to company size and legislation. In the next chapter, discussion of the results is presented.

CHAPTER 6. DISCUSSION

The research questions in this study pointed to the understanding of the Corporate Social Responsi9io0bility (CSR) reporting of Class I Railroad companies operating in the U.S. Results obtained were compared to results of similar type research, and to data obtained (i.e., emissions per carload transported). The discussion is presented by research question.

To answer the first research question: *What indicators have Class I Railroad companies reported in their CSR reports?* the concepts of Corporate Social Responsibility and Sustainability were analyzed in the literature review. Also, the research gap related to the analysis of the CSR reporting of LSPs was identified. CSR was understood as the responsibility that companies have towards societies. It was argued that the way in which companies address CSR was directly related to the society's values regarding economic, social and political ideals of the time (Bowen, 2013). The concept of sustainable freight transport was taken from international bodies. According to existing definitions, sustainable freight will aim to reduce emissions caused during transportation and to reduce road fatalities (Helmreich & Keller, 2011). Although some authors referred to CSR and sustainability as similar terms, CSR has through time been more concerned with social impacts of businesses (Cheney, Roper, May, 2007). The sustainability concept instead, has been more related with environmental concerns, especially when referring to the transport industry.

The first research question directly addresses the gap which indicated the need to understand CSR reporting in the logistics industry by sector and by transport mode (Lambrechts et al., 2019; Piecyk & Björklund, 2015b). The question was answered using the GRI, LTSS 2006 as a framework and collecting information from companies CSR reports. The GRI LTSS 2006 includes environmental, social and economic indicators developed specifically for the logistics service industry, but yet it also allows companies to report on aspects they consider material. Results were compared to other studies, specifically to Piecyk & Bjorklund (2015b) and Lambrechts et al. (2019) as authors in their research also used the GRI standards to analyze the reporting of LSPs. Other studies used for comparison were Ciliberti (2008), Colicchica et al. (2011), Evangelista (2014) and Massaroni et al. (2016). These authors also analyzed reports of LSPs, but, they did not use the GRI framework as a base. Therefore, comparisons to this study were not always possible.

Results showed which indicators Class I Railroads considered material based on those that were mostly reported on. When looking in detail to specific indicators, Class I Railroads reported more than 80% of the time on 16 of the indicators considered in this study. There were only a few differences found with the reporting of LSPs shown in previous studies. Overall, there was a high interest from companies towards their employees' wellbeing, followed by environmental aspects. From the different small groups of indicators, companies reported mostly on "labor practices and decent work" part of the social indicators 95% of the time. Studies by Piecyk & Bjorklund (2015b) and Lambrechts et al. (2019) also found that LSPs reported consistently on this group. Authors nevertheless questioned the importance given to these indicators, or the apparent importance just being part of accessibility of data (Piecyk & Bjorklund, 2015b). However, the higher interest in employees' wellbeing can be linked to the fact that the concept of CSR evolved from concerns of employees' wellbeing since its initial conception during the industrial revolution (Cheney, Roper, May, 2007). Therefore, there is a tradition of CSR giving more importance to employee's wellbeing above others.

Other groups of indicators which companies considered material were those referring to safety and to community support. The four indicators of safety that companies reported consistently on are: "health and safety" (occupational accidents and policies to reduce them), "customer health and safety" (safety during services), "road safety" (fatalities of drivers or third parties) and "training and education" (hours per employee). The importance given to safety was consistent with the results of the studies by Lambrechts et al. (2019) and Piecyk & Bjorklund (2015b). Safety is therefore a material aspect not only for the rail but for the entire logistics industry. In regards to safety indicators however, Piecyk & Bjorklund (2015b) mentioned that performance was measured in a number of ways and that a standardized set of indicators would help compare information (p. 479). For rail companies, comparisons were possible because there are two safety indicators established by the US FRA, and this analysis included only companies operating in the US. Indicators were: "Personal injury rate" (injuries per 200,000 employees) and "personal accident rate" (train accidents per one million train-miles). All companies except for NS reported regularly to these two safety indicators in their GRI and 10K or 40F reports. In addition, companies reported total fatalities (listed in the GRI framework).

Community support represented in "community" and "humanitarian programs" was reported by companies more than 90% of the time. This also coincided with the findings by Piecyk

& Bjorklund (2015b) and Ciliberti (2008), which indicated a high involvement of logistics companies in humanitarian logistics and emergency response operations. Human Rights indicators were reported by companies regularly on “non-discrimination”. Other indicators such as “child labor”, “forced and compulsory labor” and “disciplinary practices”, however, were not considered as companies did not refer to them in their reports. This was also reported by Piecyk & Bjorklund (2015b), the assumption was that companies did not perceive these topics to be an issue for their operations. The group of social indicators that railroads reported with the lowest frequency was “product responsibility” with an average of 30%. This was also the case reported by Piecyk & Bjorklund (2015b) and Lambrechts et al. (2019).

There were several differences found in the reporting of social indicators from Class I Railroads when compared to previous studies. “Product and service labeling” and “anti-corruption initiatives” were found to be material in the study by Piecyk & Bjorklund (2015b). However, this analysis found that railroads reported only 25% and 19% of the time in “product and service labeling” and “anti-corruption initiatives” respectively. Additionally, “competition and pricing” was not found to be material in this study (railroads reported only 3% of the time). Yet this indicator was also part of the SAS rail standards, it is called “competitive behavior”. Competition and pricing is related to complying with regulations and setting reasonable rates to customers (SASB, 2018). This is important, as it was previously mentioned that railroads calculate prices based on customers location and other transport opportunities they may have. Customers that have fewer options to transport are charged higher prices than those with more competitive transport options. Experts have mentioned the need to breakup railroad monopolies because 75% of the customers are served only by one railroad and sometimes and there is no option for those customers to be served by another transport mode (O’Malley, 2020).

With regard to environmental indicators reporting, railroads reported on both groups, “environmental performance” and “environmental performance for the logistics and transportation sector” consistently (76% and 65% of the time respectively). For Railroads, although important, environmental aspects on average were the second and third in importance after “labor practices and decent work”. This is slightly different to the results from previous studies. Research by Lambretchs et al. (2019), Piecyk & Bjorklund (2015b) and Massaroni et al. (2016), found that, as a group environmental indicators were reported the most by LSPs. The difference could be related to the fact that this research analyzed only one type of industry and there are indicators that are not important for this industry. The reporting of “noise & vibration” and “fleet compositions”, part of the environmental indicators was only between 10% and 16%.

Specific environmental indicators regularly reported on were related to energy consumption and initiatives to reduce energy consumption which coincide to the reporting of LSPs (See Lambretchs et al., 2019; Piecyk & Bjorklund, 2015b; Massaroni et al., 2016 and Colicchica et al., 20 11). This shows that although rail is considered one of the most efficient transport modes, the industry is also trying to improve energy efficiency in their operations.

Environmental indicators that the industry reported the lowest on were: “noise and vibration”, “fleet compositions”, and “suppliers”. LSPs also reported low in these indicators. In fact, none of those indicators were mentioned in the most common indicators list by Piecyk & Bjorklund (2015b) nor by Colicchica et al. (2011), while only “suppliers” was mentioned in the list by Lambretchs et al. (2019) but only as one of the lowest indicators companies were reporting on. Finally, there was one indicator the reporting of the railroad industry was clearly different from LSPs’ reporting: “transport infrastructure development”. This study found that companies reported this indicator an average of 89%; however, it is not mentioned on the lists of most common environmental indicators by Piecyk & Bjorklund (2015b) nor by Lambretchs et al. (2019). As previously mentioned, railroads are responsible for the construction and maintenance of infrastructure while LSPs which include companies that transport by road are not.

Overall, the reporting of Class I Railroads operating the US was found to be similar to the reporting of LSPs as identified in previous studies. Social aspects given more importance were: employees’ wellbeing, safety concerns and community & humanitarian aid, which were also important aspects mentioned by LSPs. Differences in reporting were with specific indicators: “product and service labeling” and “anti-corruption initiatives” which were not considered material for the rail industry but were for the LSPs industry. Of particular relevance is the lack of reporting of “competitive behavior” which is part of the SASB Rail Standards. Environmental indicators also had similar patterns of reporting. The most commonly environmental indicators that companies reported on were energy consumption related to GHG emissions, energy consumption by source, strategies to reduce energy consumption and strategies to use energy from renewable sources. Also they were the most important mentioned in studies by LSPs. The biggest difference in the reporting of environmental indicators when compared to LSPs is “Transport infrastructure” which was material for the rail industry, but not for the LSPs industry.

When considering stakeholder and legitimacy theories to explain companies CSR reporting, it can be argued that the reporting of Class I Railroads was related to both. Under stakeholder theory, the interests of stakeholders are considered important in addition to only interests of shareholders (Camilieri, 2007). Under legitimacy theory, instead, actions that would acceptable to societies of the time are considered important (Al Farooque & Ahulu, 2017). In the reporting of Class I Railroads, great importance was given to stakeholders' welfare, reflected in the higher reporting of employee's wellbeing, safety and community support. In addition, companies also reported highly on environmental aspects, which can be related to aspects societies consider important and acceptable.

The second research question: *What practices have Class I railroad companies reported to reduce air emissions?* This was answered using a new framework developed by the researcher during this investigation. It was developed because existing guidelines that companies were using such as: GRI, CDP and SASB lacked detailed questions to identify which aspects companies were addressing to reduce emissions. Additionally, given the nature of rail, a transport mode that can help the freight industry reduce its emissions, a framework that incorporated ideas of rail use increase was considered important. The FRF was based on previous research by Colicchia et al. (2013) and Smokers et al. (2014) and indicators or aspects that could be addressed were adapted to rail.

According to the analysis of railroad reporting based on the FRF, companies were reporting mostly on operational strategies. However, the difference between the reporting was small, on average, railroads reported on operational strategies with a QI of 1.66 and on technological strategies with a QI of 1.54 (over a maximum of 3). Similar patterns were found in the literature review. There were no specific strategies mentioned as being more relevant than others. Researchers recognized that it was the combination of strategies that has led the industry to a reduction in energy consumption (Frey & Kuo, 2007). Additionally, there was still little research carried out on the impact each indicator had over their environmental performance (Evangelista, 2014; Marchet et al., 2013).

When comparing railroads' reporting to statistics collected based on the SASB standards (percent increase or decrease of annual emissions per carload transported and carloads transported), results were mixed (See Table 6.1). From average QI of each company's reporting of the 5 years analyzed, CSX and NS had the highest QIs, 1.62 and 1.73 respectively. CSX and NS were also the companies that reduced emissions per carload transported the most: 11% and 15% respectively. However, CP, the company with the lowest QI also reduced emissions per carload significantly, 9% over the 10-year period. UP with a low average QI did not increase its energy efficiency over the 10-year period.

Table 6.1: Summary of the Freight Rail Framework Reporting and Emissions Reduction

Freight Rail Framework	**CP**	**CSX**	**NS**	**CN**	**UP**
External Operational Strategies	1.20	2.40	1.60	2.13	1.47
Internal Operational Strategies	1.40	1.75	1.70	1.45	1.60
QI Operational Strategies	1.30	2.08	1.65	1.79	1.54
Locomotive Technology	1.87	2.07	2.07	1.6	2.07
Use of Alternative Fuels	1.10	0.10	1.50	1.20	0.20
Infrastructure	1.27	1.8	1.8	1.47	1.67
QI Technological Strategies	1.41	1.32	1.79	1.42	1.31
Quality Index (QI)	**1.37**	**1.62**	**1.73**	**1.57**	**1.40**
Percent reduction of metric tons CO_2-e per carload transported	-9%	-11%	-15%	-1%	0%
Percent increase of carloads & intermodal units transported	3%	2%	17%	27%	1%

In a more detailed analysis, discrepancies were still evident. NS reported the highest QI in technological aspects, and it was also the company which achieved best results when it came to increasing its energy efficiency during the 10-year period. UP which reported the lowest QI in technological strategies was the only company that did not achieve any improvements in the 10 years. However, there was no link between the reporting of CP, CSX and CN, when compared to their emission reduction achievements. When combining the QI's of External OP, Internal OP and Infrastructure, the indicators of capacity increase; CSX, NS and CN obtained the highest QIs. Yet, from those, only NS and CN did achieve significant increase of the number of carloads transported.

While there were some links between the reporting using the FRF and the achievements in relation to reducing energy consumption and capacity increase, there are other factors that could have influenced the reporting. First, the fact that companies did not report directly answering questions from the FRF. Research of Ciliberti et al. (2008) and Piecyk & Bjorklund (2015b); found a strong connection between companies using a report and the number of initiatives being reported on. In this situation, companies did not directly respond to the FRR. Second, differences in the geography of the network means that for some companies reducing emissions and increasing capacity may be more achievable. For example CP's network is considered linear as it runs through several unpopulated areas across Canada, which decreases the need to interchange cars with other trains (Bowers, 2018). The CSX network instead, which runs along the mid-west of the USA with higher population densities has been described as spaghetti-like (Vantuomo, 2018). Other factors unique to each company can be pressure from customers, internal organization and environmental awareness.

Noticeable specific topics companies reported on are explained further. In relation to operational strategies: 1) The aspect mostly mentioned in external operations was the cooperation with government in the development of policies and projects coordinating with government and with their financial support. This was also found to be important by Evangelista et al. (2017). 2) Cooperation with customers and with other freight carriers were given less importance. These two aspects are related to themes of Precision Scheduled Railroading (PSR). Some railroads such as CP and CN, mentioned PSR concepts in their operations since 2010 (Canadian National, 2010a; Canadian Pacific, 2011a). However, most of them, CSX, NS and UP, mentioned PSR concepts only in most recent reports. One of the main strategies mentioned in the literature to increase capacity is though coordination with other freight carriers and with short-line railroads. Based on the reporting, there is a lot of room for improvement in the way companies coordinate with other transport modes and other smaller railroads.

In regards to technology improvements, companies specifically targeted investment in new locomotives and in software for improved operations along rail lines (average QI's of 2.16 and 2.08 respectively).This looks positive as researchers mention that an increase of 15 to 20% energy efficiency is expected to be achieved from engine's technology innovation (Brecher et al., 2014). The reporting of use of alternative fuels was low (Average QI of 0.82). Although according to experts not all alternative fuels reduce emissions (natural gas can increase emissions of PM, NOx and GHGs) the use of biofuels and blends with petro diesel can have a more positive impact (Brecher et al., 2014). Because of railroads' low reporting in the use of alternative fuels, there is a lot opportunity for railroads to reduce emissions using biofuels.

To answer RQ3. *What factors appear to be influencing the number of indicators being reported by class I railroad companies to reduce air emissions?* two factors were analyzed, company size and government intervention. Results showed that company size did not influence the reporting from the GRI nor by the FRF. Government intervention and support also did not have an influence on the reporting of the GRI topics. However, their influence was evident in the reporting of indicators from the FRF.

There was no consistency on the level and quality of reporting based on company size with either of the frameworks. UP (the biggest company) reported on average on a higher percentage of the GRI indicators than the other five companies. However, other large companies (NS and CN) reported on the least number of indicators during the period of study. The reporting based on the FRF showed similar results. CSX and NS, both medium-sized companies reported the highest quality of information. CP and UP, the smallest and largest companies respectively instead, reported the lowest quality of indicators.

Studies that analyzed the size of a company when compared to the level of reporting had different results based on the number of reports analyzed. Piecyk & Bjorklund (2015b) and Ciliberti et al. (2008) analyzed the reports of 45 and 83 logistics service providers respectively and found that company size was a large indicator of the number of indicators reported by companies. Obenhofer & Dieplinger (2014) instead analyzed the reports of 6 companies and found company size had no influence in the level of reporting. The lack of consistency of reporting found in this study based on company size can be related to the fact that this research is similar to the study by Obenhofer & Dieplinger (2014). The number of companies analyzed was low, 7 and 5 for the GRI and FRF respectively. More significant differences could be found if other freight railroads such as Class II and Class II railroads were included in the study and bigger differences between company sizes are found. Also, because all the companies analyzed in this study belong to a specific type, their reporting could be related to other factors such as customer pressure, competitor influence and cost reduction objectives.

Government intervention instead did seem to have an influence in the reporting of indicators from the FRF. Previous studies determined there are two ways in which government can influence the implementation of environmental strategies: with regulations and government support (Colicchia et al., 2013; Evangelista, 2014; Lin & Ho, 2011). Evangelista (2014), determined that government support was the most important aspect for the adoption of environmental initiatives. Lin & Ho (2011) explained this further by mentioning that government support can encourage the development of new technology through policies and through financial investment in such areas as projects and training programs.

In this study, government regulations and government support were found to have a relationship to companies' reporting. It was evident when analyzing companies' reporting to the FRF throughout the years. Overall, it was noted that the reporting of indicators decreased in 2016 and decreased even more in 2018. Changes in the behavior could be linked to several policy decisions: the fact that the U.S. decided to withdraw from the Paris agreement in 2017 (U.S. State Dep., 2019), which meant that the US no longer had the commitment to reduce GHGs emissions.

Similar behaviors were found in the reporting in three groups of indicators: "locomotive technology", "use of alternative fuels" and "infrastructure". Overall, there was a difference noted in the reporting of American vs. Canadian companies. American companies reported high averages of the indicators between 2010 and 2014 which dropped in 2016 and then dropped again in 2018. Canadian companies instead, although their initial reporting averages were lower than American companies, they increased or maintained their reporting in 2016 and 2018.

Tier 1-4 standards and policy to install shut down technology had an impact on the reporting of "locomotive technology". Policies not only encouraged companies upgrading their fleet, but a number of research projects in new locomotive technology were also carried out. Such as investment by UP in the development of the Genset switcher locomotive. After Tier 3 & 4 standards became mandatory in 2015, there was no knowledge of new standards coming into place to regulate emissions from locomotives by the EPA. This meant that companies were not aiming to comply with more stringent regulations, and as it was shown in Fig. 5.10, the reporting reduced in 2016 and 2018. Canadian companies instead had additional regulations though the two Memorandums of Understanding (MoU) which asked for a 6% reduction of GHG emissions during the duration of the MoU. Because the emissions of GHGs is related to the type of fuel consumed, the MoUs had an effect in Canadian companies reporting of the use of alternative fuels which was constant and increased in the last years analyzed (2016 and 2018).

Impacts of government support were evident in infrastructure investment by American companies and in alternative fuels testing by Canadian companies. A much higher reporting and investment in infrastructure was mentioned by CSX, NS an UP between 2010 and 2014. Reporting was linked to the Tiger Grants assigned to the railroad industry in 2008 and the public-private partnerships mentioned by CSX, NS and UP to upgrade corridors, build new railyards and upgrade railroads. In relation to the reporting of the use of alternative fuels by CP and CN, Transport Canada supported the research and testing on biofuels as one of three main projects aimed to reduce emissions from rail transport (Delphi & Delphi, 2019).

6.1 Summary

In this chapter a comparison of the results obtained with theories and findings from previous research was described. It was found that the reporting of Class I Railroads is very similar to the reporting of LSPs; a few differences of specific indicators were identified. Of particular importance was the fact that rail companies are not reporting on "competition and pricing" when it is listed as part of the SASB Rail Transportation Standard. The FRF offered more detail by listing many more indicators for evaluating the environmental sustainability of the rail freight industry. Results were useful to determine if companies were in fact reporting on aspects that are considered important for the rail industry. It was evident that companies are aware and are implementing several strategies to reduce emissions and increase capacity. From the two factors analyzed, company size was not evidently related to companies' reporting while legislation and government support did appear to have a strong connection with the adoption of green strategies by railroads.

CHAPTER 7. CONCLUSIONS

This research was centered on understanding the CSR reporting of Class I Railroad companies operating in the U.S. Also, the study aimed to identify which indicators Class I Railroads were implementing to reduce emissions and to increase capacity. To answer the research questions, publicly available reports filed to the GRI and to the CDP were used. Documents were analyzed using interpretive content analysis method and results were presented using basic statistics and qualitative analysis.

7.1 Summary of Findings and Contributions

There were several contributions of this research to the existing body of knowledge. 1) The reporting of Class I Railroads from the GRI was investigated which filled a research gap related to identifying aspects that rail freight companies were reporting in their CSR reports. 2) A framework was proposed to analyze the reporting of rail freight transportation. 3) An analysis was carried out of Class I Railroads reporting using the FRF. 4) Results from the analysis using the GRI and FRF were compared to determine if either company size or the legislation and government support had an impact on Railroads' reporting though the years.

First, in relation to indicators from the GRI, Class I Railroads reported consistently on five groups of indicators: a) indicators related with employee's wellbeing, b) safety indicators that include employees' and road safety, c) energy consumption, referring to emissions and type of energy consumed, d) strategies to reduce energy consumption and to reduce reliability on energy that comes from non-renewable sources, finally, e) community and humanitarian programs, referring to the delivery of relief packages. Companies also reported on most of the SASB indicators specific for rail. The only indicator from the SASB Rail Standards which companies did not report on was competition and pricing, an important aspect, as experts mention the need to break railroad monopolies (O'Malley, 2020). The fact that companies reported on most the indicators from the SASB standards means that they are not reporting only on "symbolic" or superficial aspects, but they are addressing aspects that are considered "substantial" or material for the rail industry.

Second, the FRF was developed because the existing reporting schemes (GRI, CDP and SASB) which companies were reporting to, lacked specificity. It was considered that a more detailed framework would allow the researcher to have an accurate measuring tool to determine companies' trends in implementing indicators. The FRF was based on existing research that listed aspects that can be addressed by different transportation modes to reduce their environmental impacts. Existing lists were complemented with aspects specific to the rail freight industry. The framework included aspects that were determined important to address by the rail industry: the reduction of emissions of GHGs and other pollutants; and capacity increase. Capacity increase did not directly affect the emissions reduction of the rail industry. Yet, the concept was included as there was a vast amount of literature found arguing for the increase of rail transport as a mechanism to reduce the emissions of the freight system.

Third, in the analysis of the reports based on the FRF, it was evident that railroads implemented several of the strategies to reduce emissions and to increase capacity. From the different groups of indicators, companies were relying mostly on "locomotive technology" (purchasing new locomotives and upgrading existing ones), and external operational strategies (mostly cooperation with government institutions). This indicated that companies have the potential to increase their use of alternative fuels (including biofuels), infrastructure investment and cooperation with smaller companies or other freight carriers. Reasons for implementing environmental initiatives might include reducing costs and improving the service to attract customers rather than just trying to do the right thing (Colicchia et al., 2011; Evangelista et al., 2017). Nevertheless, concepts and willingness to increase capacity and reduce emissions were reported constantly by Class I Railroads.

Given current climate change concerns, evaluating companies more accurately to determine aspects that need to be addressed to reduce their environmental impacts was essential. Also, having a framework that did not only consider a specific mode as a "silo", but as part of a system was also beneficial as their potential benefits could be encouraged. Analysis with the FRF allowed the researcher to identify in more detail areas that were, and that should be addressed by companies to reduce their environmental impacts. Consequently, results were complementary to the analysis carried out with the GRI framework. Identifying indicators companies were relying on could be used by the same Class I Railroads to detect aspects they can incorporate as part of their strategies. Additionally, information could be useful for Class II and III Railroads which may not have the resources to carry out testing, but that could benefit from the technologies mentioned.

Fourth, because of information accessibility, company size and legislation were analyzed as factors that might be affecting the reporting of Class I Railroads. Company size was not found to have a big relationship to the reporting, which contradicts results of some studies. The fact that similar companies were studied and that the number of companies was small, could be reasons for reporting not having a clear relationship to company size. However, it was noted that larger companies made heavier investments in technology and research. Although company size is not a characteristic that can be changed to improve environmental performance, it does indicate that government support could be offered to smaller companies to encourage research and investments in technology and/or infrastructure.

Legislation and government support did seem to have impacts on the practices railroads were implementing. This was seen in the reporting of the three groups of technological indicators form the FRF: 1) locomotive technology was linked to the standards set by the EPA; 2) the reporting of the use of alternative fuels, was associated to the Canadian Memorandums of Understanding; and 3) the reporting of infrastructure for American companies seemed to be influenced by government support when large public-private partnerships were mentioned between 2010 and 2016.

It is argued that it is important to allow companies to communicate their ideals through their CSR reports, as that helps them shape their behavior (Christensen, 2007). However, legislation and government support can have a bigger impact in influencing companies' behavior faster. Therefore, issues of climate change could be tackled more efficiently.

Other aspects that could be addressed with legislation and government support are encouraging Class I Railroads to cooperate with smaller Class II and III Railroads and/or with other freight transport providers. Also research and use of alternative fuels as well as investment in infrastructure should continue to be supported and encouraged by government.

7.2 Limitations of the Study and Thoughts for Future Research

Limitations of the study might be related to the methodology employed. The coding systems used for data collection did not allow to differentiate larger investments from smaller ones.

Data was collected based, either on indicators implemented or not, or on the number of projects mentioned. This could have led to companies that invested small amounts, to obtain similar AIs / QIs as other that made considerably higher investments. Other ways in which information could be collected would be by amount of money invested in each indicator.

In future research related to other transport modes, the FRF could be adapted to analyze their environmental sustainability in detail. When adapting the framework, it would be beneficial to consider: first the transport mode's advantages/disadvantages as part of the freight system; and second, the analysis of the impacts of the specific transport mode.

In future research related to the rail industry, railroads' main objectives, when implementing environmental indicators, could be investigated. Main objectives could be related to reducing costs, complying with regulations or actually reducing their environmental impact.
Other research methods such as interviews with Class I Railroads sustainability officials could be used to obtain the complementary information to this research

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APPENDIX A: LOCOMOTIVES EMISSION STANDARDS

Line Haul locomotive emission standards

Year of initial manufacture	Tier of Standards	Standards (g/bhp-hr)			
		NOx	PM	HC	CO
1973-1992a	Tier 0b	8.0	0.22	1.00	5.0
1993a-2004	Tier 1b	7.4	0.22	0.55	2.2
2005-2011	Tier 2b	5.5	e0.10	0.30	1.5
2012-2014	Tier 3c	5.5	0.10	0.30	1.5
2015 or later	Tier 4d	1.3	0.03	0.14	1.5

a Locomotive models that were originally manufactured in model years 1993 through 2001, but that were not originally equipped with a separate coolant system for intake air are subject to the Tier 0 rather than the Tier 1 standards.

b Line-haul locomotives subject to the Tier 0 through Tier 2 emission standards must also meet switch standards of the same tier.

c Tier 3 line-haul locomotives must also meet Tier 2 switch standards.

d Manufacturers may elect to meet a combined NOX + HC standard of 1.4 g/bhp-hr instead of the otherwise applicable Tier 4 NOX and HC standards, .
e The PM standard for newly remanufactured Tier 2 line-haul locomotives is 0.20 g/bhp-hr until January 1, 2013, except as specified in §1033.150(a).

Adapted from: "Federal Exhaust Emissions Standards for Locomotives" by Bureau of Transportation Statistics (U.S. BTS, 2020).

Switch locomotive emission standards

Year of initial manufacture	Tier of Standards	Standards (g/bhp-hr)			
		NOx	PM	HC	CO
1973-2001	Tier 0	11.8	0.26	2.10	8.0
2002-2004	Tier 1a	11.0	0.26	1.20	2.5
2005-2010	Tier 2a	8.1	b0.13	0.60	2.4
2011-2014	Tier 3	5.0	0.10	0.60	2.4
2015 or later	Tier 4	c1.3	0.03	c0.14	2.4

a Switch locomotives subject to the Tier 1 through Tier 2 emission standards must also meet line-haul standards of the same tier.
b The PM standard for new Tier 2 switch locomotives is 0.24 g/bhp-hr until January 1, 2013.
c Manufacturers may elect to meet a combined NOX + HC standard of 1.4 g/bhp-hr instead of the otherwise applicable Tier 4 NOX and HC standards.

Adapted from: "Federal Exhaust Emissions Standards for Locomotives" by Bureau of Transportation Statistics (U.S. BTS, 2020).

APPENDIX B: GRI LOGISTICS AND TRANSPORTATION SECTOR SUPPLEMENT INDICATORS

Environmental Performance Indicators
Materials
Energy
Water
Biodiversity
Emissions Effluents and Waste
Suppliers
Compliance
New Environmental Performance Indicators for the Logistics and Transportation Sector
Fleet Compositions
Policy
Energy
Urban Air Pollution (Initiatives to control)
Noise / Vibration
Transportation Infrastructure Development
Social Performance Indicators
Labor practices and decent work
Employment
Labor/ Management Relations
Health and Safety
Training and Education
Diversity and Opportunity
Human Rights
Strategy and Management
Non-discrimination
Freedom of Association and Collective Bargaining
Security Practices
Indigenous Rights
Society
Community
Bribery and Corruption
Political Contributions
Competition and Pricing

Product Responsibility
Customer Health and Safety
Products and Services
Advertising
Respect for Privacy
Mobile Worker Working Patterns
New Social Performance Indicators for the Logistics and Transportation Sector
Substance Abuse
Road Safety
Humanitarian Programs
Use of Labor Providers
Continuity of Employment
Economic Performance Indicators
Direct Economic Impacts
Suppliers
Employees
Providers of Capital
Public Sector
Indirect Economic Impacts

Source: GRI, 2006.

Indicator
Environmental Performance Indicators
Products and Services
Transport
Congestion
Social Performance Indicators
Human Rights
Child Labor
Forced and Compulsory Labor
Disciplinary Practices

Source: GRI, 2006.

APPENDIX C: FREIGHT RAIL FRAMEWORK

	Operational Strategies		
	Strategy	Description	References
External Operational Strategies			
1	Network cooperation. Cooperation with other freight carriers	Intermodal cooperation in railyards, and railroads with shortline railroads, truck and water transportation; Efficient operations in shared tracks; Capacity expansion through short-line network; Operations synchronization between transport modes by minimizing delays, aligning timetables and increasing load factors.	Mathers, Norsworthy & Wolfe, 2014; Becher, A., Sposanto, J & Kennedy, B., 2014
2	Cooperation with private associations / customers	Intermodal cooperation with customers; Cooperation with customers to support change from road to rail transport; Education programs on the advantage of rail transport.	Lammgaard, C., 2012 Sniden, 2019
3	Collaboration with public institutions	Cooperation with federal, state or local governments; Participation in public-private partnerships; Participation in policy development.	Evangelista, P., 2014 Herold & Lee, 2017b

	Operational Strategies		
	Strategy	Description	References
Internal Operational Strategies			
4	Railyard operations improvements (Implementation of Information technology to improve the railroad operations plan).	Precision Scheduled Railroading: improvements to the operation plan: scheduling, tracking and dispatch, reducing idling times; Customer tracking information; Trucking fast pass access at railyards; Planning of equipment management: improving equipment utilization, traffic control (operation of locomotives from a management perspective).	Dirinberger & Barkan 2007; Olesen, Power, Hvolby & Fraser, 2015; Pinto, Mistage, Bilotta & Helmers, 2018
5	Rail track operations improvement (Implementation of Information technology).	Improvements to fixed and moving block signaling; Train control signaling; Information technology devices for track maintenance control.	AASHTO, 2018 Bryan, Weisbrod & Martland, 2007
6	Driver training (fuel management)	Driver training in using train control systems / training to reduce braking loses and maintaining optimal speeds; Efficient driving can be a challenge for on-time arrivals.	Becher et al., 2014 Smokers et al., 2014
7	Management improvements to increase trains' energy efficiency	Shutting down additional locomotives; Increasing load factors by operating longer trains, spaced locomotives to reduce in-train forces and double stacking of intermodal containers; Reducing train resistance by avoiding empty slots, and minimizing gap distances. Loads should be adjusted based on adjusted slot efficiency; Uncoupling empty railcars from the end.	AASHTO, 2018; Barkan, 2007; Becher et al., 2014; Gunselmann, W., 2005; Yung-Cheg & Barkam, 2008
8	Locomotives maintenance & lubrication improvement	Improved maintenance (i.e.: top-of-the wheel lubrication). Locomotives lose energy in wheel-to-rail friction. Friction can be reduced with improved lubrication.	Becher et al., 2014; Frey & Kuo, 2007.

Technological Strategies			
	Strategy	**Description**	**References**
Locomotive Technology (Line haul and switcher locomotives)			
9	Retrofits, upgrades and energy reduction devices	Modernization of traction and propulsion system; Modernization heat, ventilation & air conditioning system; Shore connection systems (SCS): controls cabin's heating & air conditioning; Auxiliary power units & generator (APUs): shut down timers; Automatic engine stop/start systems (AESS); Retrofit of locomotives with repower kits to reduce emissions and fuel burn. Locomotives minimize fuel consumption while maintaining emissions compliance. Up to 25% fuel savings	Becher et al., 2014; Brecher & Shurland, 2015; Becher et al., 2014
10	New energy efficient locomotives & New energy efficient switcher locomotives	Dual power hybrid locomotive; two diesel engines that can switch from diesel to electric by pressing a button; Hybrid electric locomotives; uses battery stacks to recover braking energy and store it; Efficient ultra clean diesel-electric locomotives; Hybrd electric switcher locomotives; Green Goat: small diesel engine and a large battery pack; Battery electric switcher locomotive. Batteries store the regenerated braking energy from its dynamic braking system; Gensets (switcher locom., shut down automatically when idling).	Becher et al., 2014; Brecher & Shurland, 2015; Saadat et al., 2015
11	Software tools for efficient operations	Locomotive engineer assistant display and event recorder (LEADER), used to monitor fuel consumption; CSX event recorder automated download (ERAD) to monitor fuel consumption; Trip logistics and optimization software, which optimizes a locomotive's speed profile and minimizes brake; Fuel Trip Optimizer (Canadian Pacific); GE RailEdge Trip Planner.	Becher et al., 2014; Brecher & Shurland, 2015

Technological Strategies			
	Strategy	**Description**	**References**
Alternative Fuels			
12	Biofuel use	Use of biofuel mixed with diesel on different blends: Biofuel use up to 5%, between 5% - 20% and 20% +	Becher et al., 2014; Shurland et al., 2014
13	Use of other alternative fuels	Ammonia, Natural Gas locomotives, Hydrogen fuel cell locomotives, wind energy	Becher et al., 2014; Dincer et al., 2012
Asset Development and Research			
14	Cars design and upgrades	Light-weighting of train cars / insulation; Car body weight can be reduced using aluminum and stainless steel technology, plastic and others; Other technologies used can be steel frame construction.	Frey & Kuo, 2007; Gunselmann, 2005; Becher et al., 2014
15	New railyard and intermodal facilities	New railyards, having multiple terminals throughout a region allows for a reduction in truck-miles traveled; Upgrades to existing railyards.	Beherends, 2012; Bryan, 2008
16	Rail corridor investment/ Repair	Upgrades to railroads, investment in new railroads; Moving blocks investment; Upgrades to help trains moving faster along the network (increase fluidity of the network), addition of sections of double track.	ASHTO, 2018; Bryan, 2007

APPENDIX D: SCORING OF CLASS I RAILROAD REPORTS BASED ON THE GRI

	Kansas City Southern					Canadian Pacific				
	2010	**2012**	**2014**	**2016**	**2018**	**2009**	**2011**	**2014**	**2016**	**2018**
ENVIRONMENTAL PERFORMANCE INDICATORS										
Materials			1	1	1	1	1	1	1	1
Energy			1	1	1	0	1	1	1	1
Water			0	1	1	1	0	1	1	1
Biodiversity			0	1	0	1	1	1	1	1
Emissions Effluents and Waste			0	1	1	1	1	1	1	1
Suppliers			0	1	0	0	0	0	0	1
Compliance			0	1	1	1	1	1	1	0
New Environmental Performance Indicators for the L & T Sector										
Fleet Compositions			0	1	0	0	0	0	0	0
Policy			0	1	1	1	1	1	1	1
Energy			1	1	1	1	1	1	1	1
Urban Air Pollution (Initiatives to control)			1	1	1	1	1	1	1	1
Noise / Vibration			0	0	0	0	1	0	1	0
Transport Infrastructure			1	1	1	1	0	0	1	1
SOCIAL PERFORMANCE INDICATORS										
Labor practices and decent work										
Employment			0	1	1	0	1	1	1	1
Labor/ Management Relations			1	1	1	1	1	1	1	1
Health and Safety			1	1	1	1	1	1	1	1
Training and Education			1	1	1	0	1	1	0	1
Diversity and Opportunity			1	1	1	1	1	1	1	0
Human Rights										
Strategy and Management			1	1	1	0	1	0	0	1
Non-discrimination			1	1	1	1	1	1	1	0
Freedom of Association and Collective Bargaining			0	1	0	1	1	1	1	1
Security Practices			1	1	1	0	1	1	1	1
Indigenous Rights			0	0	0	0	1	0	1	0
Social Performance Indicators: Society										
Community			1	1	1	1	1	1	1	1
Bribery and Corruption			0	1	1	0	0	0	0	0
Political Contributions			0	1	0	0	0	0	0	0
Competition and Pricing			0	0	1	0	0	0	0	0

	Kansas City Southern					Canadian Pacific				
	2010	**2012**	**2014**	**2016**	**2018**	**2009**	**2011**	**2014**	**2016**	**2018**
Social Performance Indicators: Product Responsibility										
Customer Health and Safety			1	0	1	1	1	1	1	1
Products and Services			0	0	0	1	0	0	0	0
Advertising			0	0	0	0	0	0	0	0
Respect for Privacy			0	0	1	0	0	0	0	1
Mobile Worker Working Patterns			0	0	0	0	0	0	0	0
New Social Performance Indicators for the L & T Sector										
Substance Abuse			0	1	0	0	0	0	0	0
Road Safety			0	1	0	1	1	1	1	1
Humanitarian Programs			1	1	1	1	1	1	1	1
Use of Labor Providers			1	0	0	0	0	0	0	0
Continuity of Employment			1	0	1	0	0	0	0	0
ECONOMIC PERFORMANCE INDICATORS										
Direct Economic Impacts			1	1	1	1	1	1	1	1
Suppliers			1	1	1	0	1	1	1	1
Employees			0	1	1	0	1	0	0	0
Providers of Capital			0	0	0	0	0	0	0	0
Public Sector			1	1	1	0	1	0	0	1
Indirect Economic Impacts			0	0	0	0	0	0	0	0

Source: KCS data was retrieved from: 2014 (Kansas City Southern, 2014), 2016 from (Kansas City Southern, 2016), 2018 from (Kansas City Southern, 2018a). Canadian Pacific data was retrieved from: 2009 (Canadian Pacific, 2009), from 2011 (Canadian Pacific, 2011a), from 2014 (Canadian Pacific, 2014), form 2016 (Canadian Pacific, 2016) and from 2018 (Canadian Pacific, 2018).

	CSX					Norfolk Southern				
	2010	**2012**	**2014**	**2016**	**2018**	**2010**	**2012**	**2014**	**2016**	**2018**
ENVIRONMENTAL PERFORMANCE INDICATORS										
Materials	1	1	1	1	1	1	1	1	1	1
Energy	1	1	1	1	1	1	1	1	1	1
Water	0	1	1	1	1	1	1	1	0	0
Biodiversity	0	1	1	1	1	1	1	1	1	0
Emissions Effluents and Waste	0	1	1	1	1	1	1	1	1	1
Suppliers	0	1	1	1	0	0	0	1	0	1
Compliance	1	1	1	0	0	0	1	1	0	0
New Environmental Performance Indicators for the L & T Sector										
Fleet Compositions	0	1	0	0	0	0	0	1	0	0
Policy	1	1	1	1	0	1	1	1	1	1
Energy	1	1	1	1	1	1	1	1	1	1
Urban Air Pollution (Initiatives to control)	1	1	1	1	0	1	1	0	0	1
Noise / Vibration	0	0	0	0	0	1	0	0	0	0
Transport Infrastructure	1	1	1	1	1	1	1	1	1	1
SOCIAL PERFORMANCE INDICATORS										
Labor practices and decent work										
Employment	1	1	1	1	1	1	1	1	1	1
Labor/ Management Relations	1	1	1	0	1	1	1	1	1	1
Health and Safety	1	1	1	1	1	1	1	1	1	1
Training and Education	1	1	1	1	1	1	1	1	1	1
Diversity and Opportunity	1	1	1	1	1	1	1	1	1	1
Human Rights										
Strategy and Management	1	1	1	0	0	0	1	1	0	0
Non-discrimination	1	1	1	0	0	1	1	1	1	1
Freedom of Association and Collective Bargaining	0	0	0	0	0	0	0	0	0	0
Security Practices	0	1	1	1	1	0	0	0	0	0
Indigenous Rights	1	0	0	0	0	0	0	0	1	1
Social Performance Indicators: Society										
Community	1	1	1	1	1	1	1	1	1	1
Bribery and Corruption	0	0	0	0	0	0	0	0	0	0
Political Contributions	0	1	1	0	0	1	0	0	0	0
Competition and Pricing	0	0	0	0	0	0	0	0	0	0

	CSX					Norfolk Southern				
	2010	**2012**	**2014**	**2016**	**2018**	**2010**	**2012**	**2014**	**2016**	**2018**
Social Performance Indicators: Product Responsibility										
Customer Health and Safety	1	1	1	1	1	1	1	1	1	1
Products and Services	0	0	0	0	0	1	1	0	0	0
Advertising	0	0	0	0	0	1	0	0	0	0
Respect for Privacy	0	0	1	1	0	0	0	0	0	0
Mobile Worker Working Patterns	0	0	0	0	0	0	0	0	0	0
New Social Performance Indicators for the L & T Sector										
Substance Abuse	1	0	1	0	0	0	1	0	0	0
Road Safety	1	1	1	1	1	1	1	1	1	1
Humanitarian Programs	1	1	1	1	1	1	1	1	1	1
Use of Labor Providers	0	0	1	0	0	0	0	0	0	0
Continuity of Employment	0	0	0	0	0	1	0	0	0	0
ECONOMIC PERFORMANCE INDICATORS										
Direct Economic Impacts	1	1	1	0	0	1	1	1	1	1
Suppliers	1	0	0	0	0	0	0	0	1	1
Employees	1	0	0	0	0	0	0	1	1	1
Providers of Capital	1	0	0	0	0	1	1	0	0	0
Public Sector	1	0	0	0	0	0	0	1	1	1
Indirect Economic Impacts	1	0	0	0	0	0	0	0	0	0

Source: CSX data was retrieved from: 2010 (CSX Corporation, 2010), 2012 from (CSX Corporation, 2012), 2014 from (CSX Corporation, 2014), 2016 from (CSX Corporation, 2016), 2018 from (CSX Corporation, 2018). NS data was retrieved from: 2010 (Norfolk Southern, 2011a), 2012 from (Norfolk Southern, 2013b), 2014 from (Norfolk Southern, 2015b), 2016 from (Norfolk Southern, 2017b) and 2018 from (Norfolk Southern, 2019a).

	Canadian National					Union Pacific				
	2010	**2012**	**2014**	**2016**	**2018**	**2010**	**2012**	**2014**	**2016**	**2018**
ENVIRONMENTAL PERFORMANCE INDICATORS										
Materials	0	0	1	1	0	1	1	1	1	1
Energy	1	1	0	1	1	1	1	1	1	1
Water	0	1	0	0	0	1	1	1	1	1
Biodiversity	1	1	1	1	1	0	1	0	1	1
Emissions Effluents and Waste	1	1	1	1	1	1	1	1	1	1
Suppliers	1	1	1	1	1	0	0	0	0	0
Compliance	0	1	1	0	1	1	1	1	1	0
New Environmental Performance Indicators for the L & T Sector										
Fleet Compositions	0	0	0	0	0	1	0	0	0	1
Policy	1	1	1	1	1	1	1	1	1	1
Energy	1	1	1	1	1	1	1	1	1	1
Urban Air Pollution (Initiatives to control)	1	1	1	1	1	1	1	1	1	1
Noise / Vibration	0	0	0	0	0	0	0	0	0	0
Transport Infrastructure	1	0	1	0	1	1	1	0	1	1
SOCIAL PERFORMANCE INDICATORS										
Labor practices and decent work										
Employment	1	1	1	1	1	1	1	1	1	1
Labor/ Management Relations	1	1	1	1	1	0	1	1	1	1
Health and Safety	1	1	1	1	1	1	1	1	1	1
Training and Education	1	1	1	1	1	1	1	1	1	1
Diversity and Opportunity	1	1	1	1	1	1	1	1	1	1
Human Rights										
Strategy and Management	1	1	1	1	1	0	1	1	1	1
Non-discrimination	0	1	1	1	1	1	1	1	1	1
Freedom of Association and Collective Bargaining	0	1	1	1	1	0	0	0	1	1
Security Practices	0	1	0	0	0	1	1	1	1	1
Indigenous Rights	1	1	1	1	1	1	0	0	1	0
Social Performance Indicators: Society										
Community	1	1	1	1	1	1	1	1	1	1
Bribery and Corruption	0	1	1	0	0	0	1	1	0	0
Political Contributions	1	0	0	0	0	0	0	0	0	0
Competition and Pricing	0	0	0	0	0	0	0	0	0	0

	Canadian National					Union Pacific				
	2010	**2012**	**2014**	**2016**	**2018**	**2010**	**2012**	**2014**	**2016**	**2018**
Social Performance Indicators: Product Responsibility										
Customer Health and Safety	1	1	1	1	1	1	1	1	0	1
Products and Services	0	0	0	0	0	1	1	1	1	0
Advertising	0	0	0	0	0	0	0	0	1	0
Respect for Privacy	0	0	0	0	0	0	0	0	0	1
Mobile Worker Working Patterns	0	0	0	1	1	0	0	0	0	0
New Social Performance Indicators for the L & T Sector										
Substance Abuse	0	0	0	0	0	1	0	0	1	0
Road Safety	1	1	1	1	1	1	1	1	1	1
Humanitarian Programs	1	1	1	1	1	1	1	1	1	1
Use of Labor Providers	1	1	1	1	1	1	0	1	1	1
Continuity of Employment	0	0	0	0	0	1	1	1	1	1
ECONOMIC PERFORMANCE INDICATORS										
Direct Economic Impacts	1	1	1	1	1	1	1	1	1	1
Suppliers	0	1	1	1	1	1	1	1	1	1
Employees	0	0	0	0	0	1	1	1	1	1
Providers of Capital	0	0	1	1	1	0	0	0	0	0
Public Sector	0	2	1	1	1	0	0	0	0	0
Indirect Economic Impacts	0	0	0	0	0	0	0	0	0	0

Source: Canadian National data was retrieved from: 2010 (Canadian National, 2010a), 2012 from (Canadian National, 2012b), 2014 from (Canadian National, 2014b), 2016 from (Canadian National, 2016b), 2018 from (Canadian National, 2018b). Union Pacific data was retrieved from: 2010 (Union Pacific, 2010a), 2012 from (Union Pacific, 2012a), 2014 from (Union Pacific, 2014a), 2016 from (Union Pacific, 2016a) and 2018 from (Union Pacific, 2018b).

	BNSF		
	2013	**2015**	**2017**
ENVIRONMENTAL PERFORMANCE INDICATORS			
Materials	0	0	0
Energy	1	1	1
Water	0	0	0
Biodiversity	1	1	1
Emissions Effluents and Waste	1	1	1
Suppliers	1	1	1
Compliance	1	1	1
New Environmental Performance Indicators for the L & T Sector			
Fleet Compositions	0	0	0
Policy	1	1	1
Energy	1	1	1
Urban Air Pollution (Initiatives to control)	1	1	1
Noise / Vibration	0	0	0
Transport Infrastructure	1	1	1
SOCIAL PERFORMANCE INDICATORS			
Labor practices and decent work			
Employment	1	1	1
Labor/ Management Relations	1	1	1
Health and Safety	1	1	1
Training and Education	1	1	1
Diversity and Opportunity	1	1	1
Human Rights			
Strategy and Management	1	1	1
Non-discrimination	1	1	1
Freedom of Association and Collective Bargaining	1	0	1
Security Practices	0	0	0
Indigenous Rights	1	1	1
Social Performance Indicators: Society			
Community	1	1	1
Bribery and Corruption	0	0	0
Political Contributions	1	1	1
Competition and Pricing	0	0	0

	BNSF		
	2013	**2015**	**2017**
Social Performance Indicators: Product Responsibility			
Customer Health and Safety	0	1	1
Products and Services	1	1	1
Advertising	0	0	0
Respect for Privacy	0	0	0
Mobile Worker Working Patterns	0	0	0
New Social Performance Indicators for the L & T Sector			
Substance Abuse	0	0	0
Road Safety	1	1	1
Humanitarian Programs	1	1	1
Use of Labor Providers	0	0	0
Continuity of Employment	0	0	1
ECONOMIC PERFORMANCE INDICATORS			
Direct Economic Impacts	0	1	1
Suppliers	0	0	0
Employees	0	1	0
Providers of Capital	0	0	1
Public Sector	0	0	0
Indirect Economic Impacts	0	0	0

Sources: BNSF data was retrieved from: 2013 from (BNSF, 2013), 2015 from (BNSF, 2015), and 2017 from (BNSF, 2017).

APPENDIX E: SCORING OF CLASS I RAILROADS BASED ON THE FREIGHT RAIL FRAMEWORK

	Canadian Pacific					CSX				
Indicator	2009	2011	2014	2016	2018	2010	2012	2014	2016	2018
Operational Strategies										
External Operational Strategies										
Cooperation w/ other freight carriers	1	1	1	1	0	3	2	3	3	2
Cooperation w/ private associations / customers	0	1	1	2	1	2	3	3	3	2
Collaboration with public institutions	2	2	2	2	1	2	2	2	2	2
Internal Operational Strategies										
Railyard & rail road operation improvements	2	0	2	3	3	1	2	2	2	3
Driver training (fuel management)	1	0	1	1	1	2	2	2	2	2
Train area marshalling	2	2	1	2	1	1	2	2	3	3
Locomotives maintenance & lubrication	2	2	1	1	0	1	1	1	1	0
Technological Strategies										
Locomotive Technology										
Energy efficient and Idle Reduction Control Devices	2	2	1	1	2	2	2	2	2	2
New energy efficient locomotives	3	2	2	2	2	2	2	1	2	0
Software tools for stream less operations	1	2	1	2	2	2	3	3	3	3
Alternative Fuels use										
Biofuel use	2	1	1	1	2	0	0	0	0	0
Other alternative fuels	0	1	1	1	1	0	0	1	0	0
Infrastructure and Research										
Cars design and upgrades	1	1	1	1	2	1	2	1	0	0
Rail corridor inv. Repair	1	1	1	2	2	3	2	2	2	2
Railyard and intermodal facilities investment	1	1	1	1	2	2	3	3	3	1
Technology research investment and testing	1	2	2	1	2	1	1	2	0	1

Source: Canadian Pacific data was retrieved from: 2009 (Canadian Pacific, 2009, 2010), from 2011 (Canadian Pacific, 2011a, 2012), from 2014 (Canadian Pacific, 2014, 2015), form 2016 (Canadian Pacific, 2016, 2017) from 2018 (Canadian Pacific, 2018, 2019). CSX data was retrieved from: 2010 (CSX Corporation, 2010, 2011) 2012 from (CSX Corporation, 2012, 2013), 2014 from (CSX Corporation, 2014, 2015), 2016 from (CSX Corporation, 2016, 2017), 2018 from (CSX Corporation, 2018, 2019).

Indicator	Norfolk Southern 2010	2012	2014	2016	2018	Canadian National 2009	2011	2014	2016	2018
Operational Strategies										
External Operational Strategies										
Cooperation w/ other freight carriers	2	1	0	0	1	2	2	2	2	2
Cooperation w/ private associations / customers	2	3	3	1	2	2	2	2	3	1
Collaboration with public institutions	2	2	3	1	1	3	2	2	2	3
Internal Operational Strategies										
Railyard & rail road operation improvements	3	3	3	2	3	2	2	2	2	3
Driver training (fuel management)	1	1	1	1	2	2	1	1	1	2
Train area marshalling	2	2	2	1	1	1	1	2	1	2
Locomotives maintenance & lubrication	2	2	2	0	0	1	1	1	0	1
Technological Strategies										
Locomotive Technology										
Energy efficient and Idle Reduction Control Devices	2	2	2	1	2	1	1	1	1	1
New energy efficient locomotives	3	3	3	2	1	2	3	2	2	2
Software tools for stream less operations	2	2	2	2	2	0	2	2	2	2
Alternative Fuels use										
Biofuel use	2	3	1	1	1	1	1	0	1	2
Other alternative fuels	2	2	3	0	0	1	2	2	1	1
Infrastructure & Research										
Cars design and upgrades	2	2	2	0	0	1	0	1	0	1
Rail corridor investment/ Repair	3	3	3	2	1	2	2	2	2	2
Railyard and intermodal facilities investment	2	2	3	1	1	1	1	2	3	2
Technology research investment and testing	3	3	3	1	1	2	2	1	1	2

Source: NS data was retrieved from: 2010 (Norfolk Southern, 2011a, 2011b), 2012 from (Norfolk Southern, 2013b, 2013a), 2014 from (Norfolk Southern, 2015b, 2015a), 2016 from (Norfolk Southern, 2017b, 2017a) and 2018 from (Norfolk Southern, 2019a, 2019b). Canadian National data was retrieved from: 2010 (Canadian National, 2010a, 2011), 2012 from (Canadian National, 2012b, 2013), 2014 from (Canadian National, 2014b, 2015), 2016 from (Canadian National, 2016b, 2017), 2018 from (Canadian National, 2018b, 2019).

	Union Pacific				
Indicator	2009	2011	2014	2016	2018
Operational Strategies					
External Operational Strategies					
Cooperation w/ other freight carriers	0	0	2	2	1
Cooperation w/ private associations / customers	1	1	1	1	2
Collaboration with public institutions	3	2	2	2	2
Internal Operational Strategies					
Railyard & rail road operation improvements	2	2	1	2	3
Driver training (fuel management)	3	3	2	1	1
Train area marshalling	3	2	1	2	0
Locomotives maintenance & lubrication	2	1	0	1	0
Technological Strategies					
Locomotive Technology					
Energy efficient and Idle Reduction Control Devices	2	2	2	1	0
New energy efficient locomotives	3	3	3	2	2
Software tools for stream less operations	1	2	3	3	2
Alternative Fuels use					
Biofuel use	0	0	0	0	0
Other alternative fuels	0	0	1	1	0
Infrastructure & Research					
Cars design and upgrades	1	1	1	1	0
Rail corridor investment/ Repair	2	3	2	2	2
Railyard and intermodal facilities investment	3	3	1	2	1
Technology research investment and testing	2	3	2	2	2

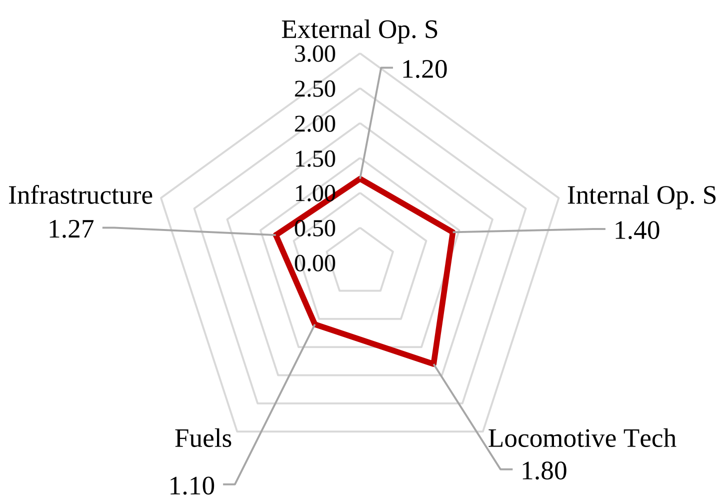
Source: Union Pacific data was retrieved from: 2010 (Union Pacific, 2010a, 2011), 2012 from (Union Pacific, 2012a, 2013), 2014 from (Union Pacific, 2014a, 2015), 2016 from (Union Pacific, 2016a, 2017) and 2018 from (Union Pacific, 2018b, 2019).

APPENDIX F: SUMMARY OF PRACTICES ADOPTED BY EACH RAILROAD

The following section includes an analysis of the type of the significant projects each company has implemented based on the FRF. Radar charts for the reporting of each company were used to demonstrate their performance separately when there are several ‘groups’ of performance as per Colicchia, et al. (2011).

Every axis of the radar chart represents a group of indicators (i.e. operational strategies have two groups of indicators: external and internal strategies; and technological strategies have three groups of indicators: locomotive technology, alternative fuels and infrastructure and research). The center of the chart, indicates a quality index (QI) of zero, meaning that no indicators were adopted between 2010 and 2018. The outer line represents a score of 3, which means that a company reported a higher quantity and quality of information related to indicators contained in that group.

Canadian Pacific



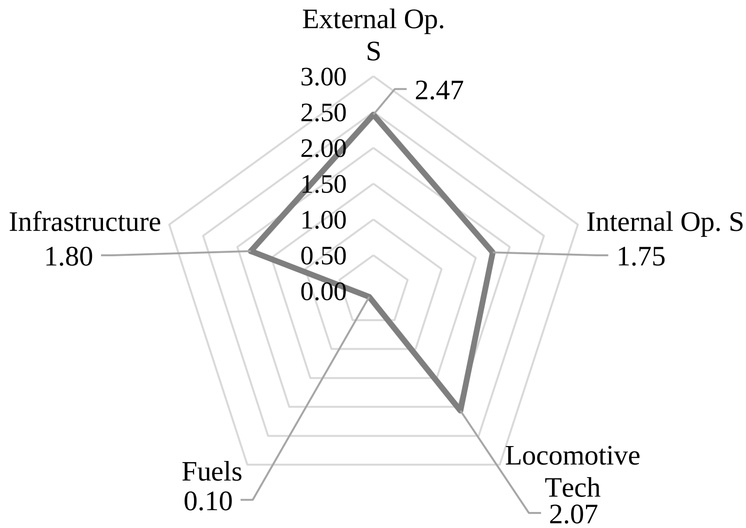
Canadian Pacific, Freight Rail Framework Reporting

Strategies Canadian Pacific mentioned in most reports to reduce emissions and increase capacity were technology upgrades to its locomotives, internal operational strategies and the use and testing of alternative fuels. CP reported an investment of 1.5 billion in new fleet (47% new fleet) between 1995 and 2011, which produced 60% less pollution and used 20% less fuel than previous models (Canadian Pacific, 2011a). Between 2011 and 2018, the company mentioned the retrofitting of electric-diesel locomotives, rather than buying new locomotives as a way to upgrade their fleet. In 2014, CP invested in the remanufacture of 567 engines (Canadian Pacific, 2014). Beginning in 2017 and though to 2024 the company planed to undergo a fleet renewal project which included the upgrade and retrofit of 321 locomotives (advanced diesel engines, new heating and cooling systems and improved traction systems) (Canadian Pacific, 2019).

Significant reference was made to Operational Strategies in the five reports analyzed. Concepts of Precision Scheduled Railroading were mentioned since 2011 when Hunter Harrison became CP's CEO. Strategies mentioned were focused in reducing traveling and idling times by reducing bottlenecks in railyards, implementing train scheduling models and operating longer and double stack trains (Canadian Pacific, 2014). Finally, the testing and use of alternative fuels was mentioned the 2009, 2016 and 2018 reports. CP tested the use of biodiesel blends, liquefied natural gas, hybrid fuel cell and battery hybrid technologies during the past decade (Canadian Pacific, 2010, 2019). Although, the use of renewable fuel by CP was low (CDP reports show that on average only about 0.01% of the total fuel consumed by CP has come from renewable sources), the company continues with the testing of alternative fuels because of regulatory reasons (Canadian Pacific, 2017).

CSX

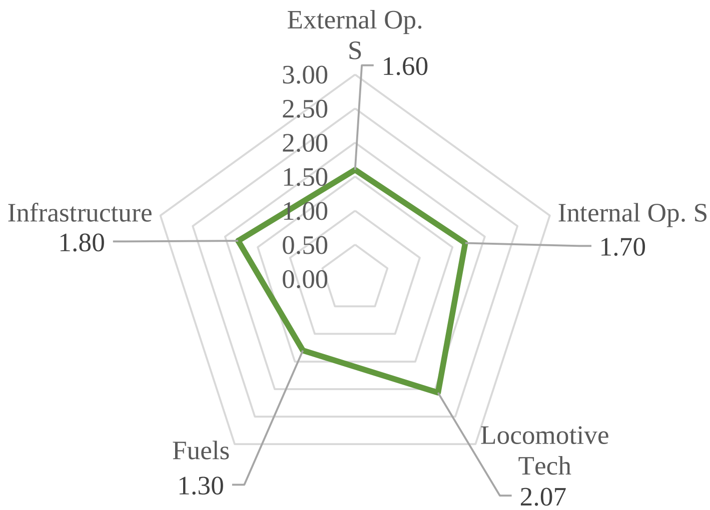
CSX relied mostly on technological strategies and on the development of infrastructure to reduce emissions and increase capacity. The largest investment CSX mentioned was the implementation of the "National Gateway" project, a public-private partnership between CSX and the government. The project was to co-fund $842 million to address the demand for increase capacity of the rail freight network by creating an efficient link between the Mid-Atlantic ports and the Midwest (CSX Corporation, 2010). Some of the completed infrastructure included: upgrades of tracks and corridors to allow for double-stack trains and the construction and upgrade of railyards. The project was launched in 2008 and CSX reported advances in its implementation and investment of over $1 billion dollars until its 2018 CSR report (CSX Corporation, 2019).



CSX, Freight Rail Framework Reporting

As for technological strategies, the company mentioned in its CDP reports the purchase of new switcher and long haul locomotives between 2010 and 2016 (CSX Corporation, 2011, 2013, 2015, 2017). For example CSX purchased 300 Tier 4 locomotives in 2017. The company also reported investing more than $ 2.8 billion since 2010 in fuel-saving locomotive technologies (CSX Corporation, 2019). Other technologies such as automated engine start/stop systems to reduce idling and trip optimizer to reduce fuel consumption, were also mentioned in reports between 2010 and 2018 (CSX Corporation, 2011, 2013, 2015). Finally PSR strategies which are related to internal operational strategies were mentioned in their 2016 report with the idea of offering a more efficient service for customers but also to improve safety for employees and communities (CSX Corporation, 2016).

Norfolk Southern

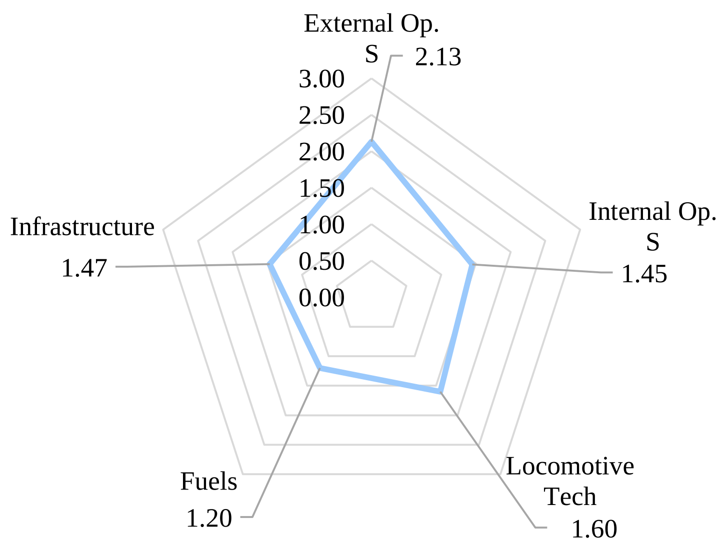


Norfolk Southern, Freight Rail Framework Reporting

Norfolk Southern, similar to CSX, invested heavily in infrastructure between 2010 and 2012 to increase capacity. Although infrastructure investment continued through 2014 and 2016, smaller projects were mentioned since 2014. Infrastructure projects included: improvement of corridors that allowed for double stalk trains to circulate and construction of new intermodal terminals (Norfolk Southern, 2011a, 2013a). As part of the infrastructure investment NS made public and private partnerships with federal government and other railroads such as (UP and BNSF) to share investment costs (Norfolk Southern, 2011a). Norfolk Southern also invested in the testing the use of alternative fuels between 2010 and 2014, several projects were mentioned such as testing of a synthetic diesel from animal fat and grease (Norfolk Southern, 2013a) and use of a vegetable-based biodiesel (Norfolk Southern, 2011a). According to data from their CDP reports, on average 1.07% of the total fuel consumed by NS came from renewable sources.

In regards to operational strategies, NS reported constantly tools used to improve operations management, with the implementation of software to coordinate movement across the network (Norfolk Southern, 2011a). NS mentioned in its 2018 report, precision railroading initiatives to increase operating efficiency (Norfolk Southern, 2019a).

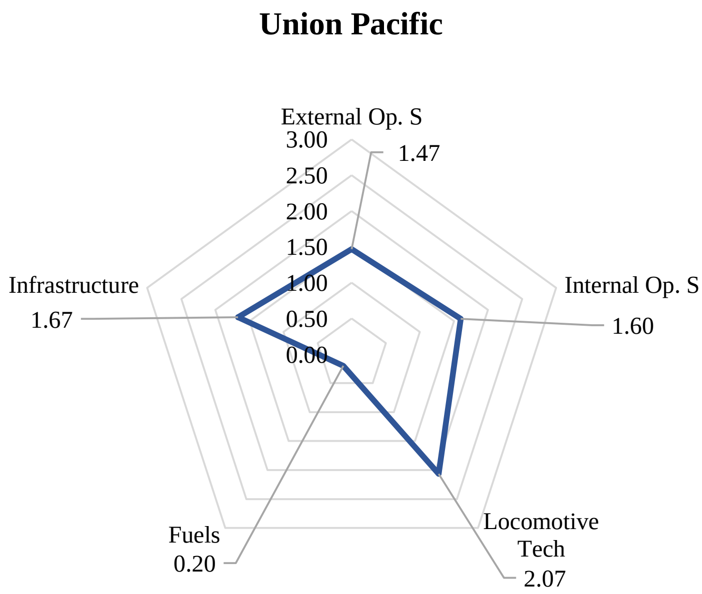
Canadian National



Canadian National, Freight Rail Framework Reporting

There were three main aspects Canadian National mentioned as main strategies to reduce emissions caused by locomotives. First, Precision Scheduled Railroading (PSR), which was mentioned in every report between 2010 and 2018, which included several operational and technological actions aimed at operational efficiency. Canadian National collaborated with ports, customers and other Class I Railroads to reduce idling times in railyards and traveling times along the network (Canadian National, 2012b, 2014b). Also, the company installed software in locomotives such as trip optimizer and automatic stop/start systems to optimize traveling times and reduce emissions (Canadian National, 2012b, 2016b). Second, CN invested in testing and use of alternative fuels (Liquefied Natural Gas and biodiesel). In the 2012 report, the testing of LNG locomotives was mentioned, and later in 2014 two locomotives were retrofitted to run with LNG and Diesel (Canadian National, 2014). Later reports from 2016 and 2018 mentioned the use of biodiesel blends in their locomotive fleet as a result of "regulatory requirements" (Canadian National, 2016b, 2018b). Additionally, the reports mentioned that CN hoped to increase the use of biofuel blends in their locomotives in the future (Canadian National, 2018b).

Finally, the acquisition of new fleet was also a key strategy for reducing air emissions. The acquisition of new fuel efficient locomotives to comply with new standards was mentioned in every report. Acquisitions from 2010 and 2012, to comply with Tier 2 standards which came into place in the year 2000; and from 2014 onwards to comply with Tier 3 and 4 regulations which came into effect in 2015.



Union Pacific, Freight Rail Framework Reporting

The two main strategies were mentioned by Union Pacific in its reports to reduce emissions and increase capacity were: investment in locomotive technology and investment in large infrastructure projects. The purchase of at least 100 new locomotives was mentioned in every report between 2010 and 2016, except in 2018 when UP purchased 51 new locomotives (Union Pacific, 2018b). Locomotives were purchased to comply with emissions standards, Tier 0, 1 and 3 in 2010, 2012 and locomotives from 2014 onwards to comply with Tier 3 and 4 standards. UP also invested in the research and testing of energy efficient switcher locomotives, the company considered itself a pioneer of the Genset switcher Locomotive (Union Pacific, 2012a). Other technology investments mentioned were the implementation of idle reduction technology, installation of automatic stop/start systems and travel recording software to locomotives (Union Pacific, 2014a).

Second, large infrastructure projects were mentioned in all the reports between 2010 and 2018. One of the company's main projects was CREATE (a collaboration with the US DOT, State of Illinois, the City of Chicago and other Class I Railroads), which focused in reducing traffic congestion by improving rail junctions and crossings mostly in the Chicago area (Union Pacific, 2012a). Some of the developments form the CREATE project included new overpasses or underpasses to separate passengers from freight rail (Union Pacific, 2018b). Other infrastructure investments included the development of the Alameda corridor running between Long Beach and downtown Los Angeles in 2010 (Union Pacific, 2010a) and a new container export facility completed in Arizona in 2016 (Union Pacific, 2016a). Precision Scheduled railroading related to operational efficiency was only mentioned in the 2018 report as a mechanism to move cars faster and to reduce dwell times (Union Pacific, 2018b).