The Value of Commercial Marine Shipping to Canada

The Expert Panel on the Social and Economic Value of Marine Shipping to Canada

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

THE VALUE OF COMMERCIAL MARINE SHIPPING TO CANADA

The Expert Panel on the Social and Economic Value of Marine Shipping to Canada

THE COUNCIL OF CANADIAN ACADEMIES
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This report was prepared for Clear Seas Centre for Responsible Marine Shipping (Clear Seas). Any opinions, findings, or conclusions expressed in this publication are those of the authors, the Expert Panel on the Social and Economic Value of Marine Shipping to Canada, and do not necessarily represent the views of their organizations of affiliation or employment or the sponsoring organization, Clear Seas.

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Science Advice in the Public Interest

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Expert Panel on the Social and Economic Value of Commercial Marine Shipping to Canada

Under the guidance of its Scientific Advisory Committee, Board of Governors, and Member Academies, the CCA assembled the Expert Panel on the Social and Economic Value of Commercial Marine Shipping to Canada to undertake this project. Each expert was selected for his or her expertise, experience, and demonstrated leadership in fields relevant to this project.

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Message from the Chair

One of the biggest challenges faced by the shipping industry is being "out of sight, out of mind." Canada is a major trading nation, and its dependence on shipping is underappreciated as a result. Many Canadians neither equate a "Made in South Korea" label with their own economic prosperity nor recognize the need for Canadian exports to reach foreign markets so that, in turn, Canadians can have choices in their purchases at home.

While shipping is an enabler of globalized trade, its impacts are broader than just those seen in our local port communities. That is why this report addresses national, regional, and local issues. Shipping cannot be held accountable for the ills of globalization; that is a matter for public policy-makers and beyond the scope of this report.

The wording of the charge challenged the Panel. To examine the social and economic value of shipping to Canada indicated a methodological scope greater than the traditional economic impact study. There are many more research disciplines than just the science of economics, so which ones to use became a key decision early in the Panel's deliberations. Furthermore, each company, organization, level of government, and individual member of civil society will appraise the value of shipping according to the values that they hold. The Panel's holistic approach to the charge recognizes those many perspectives and reflects the multidisciplinary composition of the Panel.

I would like to thank the Council of Canadian Academies for assembling such a diverse assessment panel as I believe that diversity enhances quality. CCA staff did an excellent job in translating discussion into text but, in the end, the Panel takes responsibility for the conclusions that it presents. My personal thanks is also given to each of the panellists. They donated their time and expertise, listening to, examining, and understanding the variety of approaches to the assessment of the value of shipping to Canada. They also took the time needed to diplomatically reconcile their sometimes opposing viewpoints. Finally, I hope that readers will want to understand the complexity of this topic and read this report in its entirety.

Thank you to the CCA for trusting me with this challenge and honour.

Mary R. Brooks, Chair
Expert Panel on the Social and Economic Value of Commercial Marine Shipping to Canada

Message from the President and CEO

Canada's economy, culture, environment, and security have long been interlinked with commercial marine shipping. Critical to Canada's historical development, marine shipping continues to be vital to international trade and the development of communities. It is often the only means by which to ensure food and essential goods reach remote communities.

While it is evident that marine shipping is of critical importance to Canada, its value has never been comprehensively assessed. What would Canada look like without the marine shipping industry? What is the value of marine shipping to Canada? How can the social value of marine shipping be assessed in addition to the economic value?

To help understand this issue, Clear Seas Centre for Responsible Marine Shipping asked the CCA to undertake an expert panel assessment on the topic. We assembled a multidisciplinary, multi-sectoral panel of 10 experts with a range of expertise, experience, and demonstrated leadership in economics, sociology and cultural studies, the marine shipping industry, and marine shipping-related public policy. The resulting report, *The Value of Commercial Marine Shipping to Canada*, combines a review of both academic and grey literature, original data analysis and case studies, and a novel modelling exercise to help understand the role of marine shipping in the Canadian economy. It is a comprehensive study — the first of its kind to examine "value" as including cultural, environmental, and security dimensions in addition to economic measures.

I would like to thank Dr. Mary R. Brooks, the Chair of the Expert Panel, and her fellow panel members for their efforts to bring this project through to completion. Our Board of Governors, Scientific Advisory Committee, and the CCA's three founding Member Academies — the Royal Society of Canada, the Canadian Academy of Engineering, and the Canadian Academy of Health Sciences — provided key guidance and input throughout the entire assessment process.

Finally, I'd like to thank Clear Seas Centre for Responsible Marine Shipping for referring this important project to the CCA.

Eric M. Meslin, PhD, FCAHS
President and CEO, Council of Canadian Academies

Acknowledgements

Over the course of its deliberations, the Panel sought assistance from individuals and organizations that provided valuable evidence and information for consideration. Lorenzo Caliendo (Yale University) and Fernando Parro (Johns Hopkins University) developed and simulated a quantitative general equilibrium trade model, which informed the Panel's assessment of the national economic value of commercial marine shipping. Ray Johnston (Chamber of Marine Commerce; Green Marine Management Corporation) presented the findings of research on the economic, social, and environmental impacts of marine shipping in the Great Lakes–St. Lawrence Seaway System. Gord McKenna (Canadian Tire Corporation) provided an informative overview of the role of marine shipping to Canadian Tire's global sourcing. Finally, the Port of Montréal hosted the Panel for a tour and overview of their operations. The Panel is thankful for these helpful contributions.

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Peer Review

This report was reviewed in draft form by the individuals listed below — a group of reviewers selected by the Council of Canadian Academies for their diverse perspectives, areas of expertise, and broad representation of academic, industrial, policy, and non-governmental organizations.

The reviewers assessed the objectivity and quality of the report. Their submissions — which will remain confidential — were considered in full by the Panel, and many of their suggestions were incorporated into the report. They were not asked to endorse the conclusions, nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the authoring Panel and the CCA.

The CCA wishes to thank the following individuals for their review of this report:

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The peer review procedure was monitored on behalf of the CCA's Board of Governors and Scientific Advisory Committee by **Eddy Isaacs, FCAE,** President, Eddy Isaacs, Inc. and Strategic Advisor, Engineering, University of Alberta. The role of the peer review monitor is to ensure that the Panel gives full and fair consideration to the submissions of the report reviewers. The Board of the CCA authorizes public release of an expert panel report only after the peer review monitor confirms that the CCA's report review requirements have been satisfied. The CCA thanks Dr. Isaacs for his diligent contribution as peer review monitor.

Executive Summary

As a maritime nation, Canada's economy, culture, environment, and security have long been interlinked with commercial marine shipping. Marine shipping was critical to the country's historical development, contributing to the location and evolution of major cities and smaller communities alike. Today, marine shipping facilitates international trade and is often the only means of moving essential goods to Canada's island, remote, and northern communities. Marine shipping, along with other modes of transportation, is, however, a source of greenhouse gases (GHGs) and air pollution. It can also cause spills and port-related noise and congestion, provide a means of supporting crime and terrorism, and have significant cultural impacts on coastal communities.

The value of marine shipping to Canada has never been comprehensively assessed. Clear Seas Centre for Responsible Marine Shipping (Clear Seas) therefore asked the Council of Canadian Academies (CCA) to undertake an expert panel assessment on the topic. Specifically, Clear Seas asked the following questions:

> *What is the social and economic value of commercial marine shipping to Canada and its regions? How will global trends related to shipping affect future shipping activity in Canada?*

To address the charge, the CCA assembled a multidisciplinary and multisectoral panel of 10 experts (the Panel). For more than a year, the Panel reviewed, analyzed, and interpreted the best available evidence on marine shipping and its value. This included both academic and grey literature, original data analysis and case studies, and state-of-the-art trade modelling. Ultimately, the Panel determined that no single estimate or perspective could account for the value of commercial marine shipping to Canada, but that a comprehensive approach was required. The Panel then defined four dimensions of value: economic, cultural, environmental, and security. Panel members also agreed that *values* — the moral precepts that inform understandings of the world — influence in part how they understand and assess the *value* of an activity like marine shipping.

COMMERCIAL MARINE SHIPPING IN CANADA: PAST, PRESENT, AND FUTURE

For millennia before European settlement, Indigenous peoples engaged in marine trade. Long-standing Indigenous trade routes traversed inland and coastal waterways. Canoes, kayaks, and other vessels were used to move a range of goods, including animal hides, fish, and shell ornaments. To facilitate early

trade, colonial settlers relied upon local Indigenous knowledge and the location of Indigenous communities along these established routes. As marine shipping was the only way to move large volumes of goods over long distances, marine trade expanded rapidly at these early ports. Canadian staples such as fur, fish, and timber flowed to Europe and commodities such as cloth, guns, and luxuries flowed in return. Major Canadian cities, such as Montréal and Halifax, and numerous other coastal communities, have their origins in this early marine shipping. The extraction and export of commodities was central to Canada's early economic growth and political development, but the resulting economic activity contributed to over-fishing, forest degradation, and biodiversity loss. This growing marine trade also disrupted and displaced Indigenous marine transportation and trade networks, and ways of life. By moving people, marine ships contributed to the spread of European disease and conflict, facilitated colonization, and led to widespread depopulation among Indigenous peoples.

Today, marine trade within Canada occurs across the entire country. Most of this volume is in a small number of bulk commodities such as forest products, iron ore, and crude oil. Marine shipping also transports general cargo, such as essential food, fuel, and machinery, to island, remote, and northern communities. Without marine shipping, essential goods would be much more expensive on Vancouver Island, on the island of Newfoundland, and in Northern Canada, for example. Some goods would not be available at all. Indeed, due to a lack of road or rail access, communities in the Canadian Arctic are almost entirely dependent on marine shipping for the import of essential goods.

Marine shipping transports about 20% of Canadian exports and imports by dollar value. In 2015, marine trade was valued at $205 billion, with about 80% outside North America. Canada differs from most other countries in that it both exports and imports large volumes of the same bulk commodities (e.g., oil, coal, iron ore, and wheat). This reflects its unique geography and transportation costs: Canada is a vast country with an uneven distribution of natural resources. It imports a diverse range of container cargo (e.g., vehicles, consumer goods, machinery and equipment, and intermediate imports). This is similar to other developed countries, reflecting integration in global supply chains.

In the future, marine shipping will evolve in the face of global social forces that determine the arrow of human history, such as population and income growth, scientific and technological progress, environmental and ecological change, and cultural and political evolution. By shaping the societies in which trade occurs, these forces also influence marine and other modes of transportation. Global population and income growth will almost certainly increase global trade. Canada will likely continue both to export fossil fuels and liberalize trade

although that could change in response to global economic and geopolitical trends. To some extent, these trends will be balanced by structural economic changes, political movements, and environmental and safety concerns. In the Panel's view, however, the overall effect of these trends will likely increase future marine shipping activity in Canada. Whether this is to be judged as positive or negative depends, in part, on one's perspective on these forces — that is, on one's values.

By moving goods and people, marine shipping has played a formative role in Canada's history. Today, despite other competing modes of commercial transportation, marine shipping remains — and will likely continue to remain — an important part of Canada's economy and culture.

DIMENSIONS OF VALUE

To comprehensively assess the value of commercial marine shipping to Canada, the Panel reviewed the evidence on its economic, cultural, environmental, and security impacts.

Economic Impacts

At the national level, the Canadian commercial marine shipping industry directly contributes $3 billion to gross domestic product (GDP). However, conventional measurement of GDP fails to capture its primary economic impact. By facilitating international marine trade, marine shipping helps shape specialized production and trade patterns that would be less efficient or perhaps not exist otherwise. By incorporating insights from both international trade and transportation economics, the Panel's quantitative trade model takes these patterns as well as transportation costs into account. It estimates that without shipping, Canada's long-run real GDP would be permanently reduced by 1.8% or around $30 billion in 2016. This is about nine times larger than the industry's GDP and roughly the size of the 2016 Canadian agricultural sector or New Brunswick's economy.

This trade affects virtually every industry, region, and community across the country but to differing degrees. The metallurgical coal industry in Western Canada and the wheat and canola industry in the Prairies depend on marine shipping for exports to Asia and other markets outside of North America. Atlantic Canada is dependent on marine shipping for exporting oil to the United States and importing it from Africa, the Middle East, and Europe. Manufacturing industries in Central Canada rely on marine shipping to access global supply chains. Intermediate imports are often carried by ship to Canadian firms, later to be re-exported as final goods, often to the United States. Within Canada,

regional marine trade is in a small number of bulk commodities, such as forest products, iron ore, and crude oil, which are used in manufacturing industries. Marine trade, both international and domestic, is a source of employment across Canada. In addition, the Canadian marine shipping industry itself is a direct and indirect source of some 99,000 jobs across the country. These jobs account for approximately $4.6 billion in labour income nationally, and are a substantial source of local employment in some coastal regions and port communities.

Cultural Impacts

Marine shipping remains tightly woven into Canadian culture today, influencing symbols, beliefs, and identities. Marine ships, such as the canoe, *Bluenose*, and *Amundsen*, are important national symbols. Most Canadians believe that they are citizens of a maritime or seafaring nation and that marine shipping is an important part of Canada's culture. The social significance of marine-related employment is not fully reflected in the employment metrics indicated above. Employment is a critical component of individual identity and in the organization of social life in regions and communities. Commercial ships transport a diverse range of goods, such as vehicles, furniture, clothing, electronics, and other consumer products. Consumption of these goods helps define the identities of most Canadians and increases their well-being.

Shipping activity has contributed to the cultural development of Canada's port cities and coastal regions. The Pacific region, the Great Lakes, Atlantic Canada, and the Arctic have distinct maritime cultures and traditions that are often represented in local maritime museums and cultural events. There are also distinct sub-cultures within port cities, including those of longshoremen and mariners. Many negative environmental impacts of shipping tend to be localized, arising in response to port and shipping operations. These impacts can be particularly acute for Indigenous peoples. Marine shipping can damage culturally and ecologically sensitive coastal areas and disrupt traditional fishing and hunting. In the Arctic, the passage of commercial marine ships, icebreakers, and research vessels can sometimes prevent hunters and fishers from getting to traditional areas, potentially stranding them on the ice, and affect marine mammal populations.

Environmental Impacts

Environmental impacts associated with commercial marine shipping include localized air and water pollution, effects on marine ecosystems and species, port-related noise and light pollution and traffic congestion, the introduction of invasive species, and risks arising from marine accidents and spills. The magnitude and costs of these impacts can be significant where they occur; however, many are declining because of new regulations and port initiatives.

Localized air pollution associated with shipping is declining in response to the creation of Emissions Control Areas, for example, and the rates of introduction of invasive species into the Great Lakes have fallen since the introduction of new regulations governing ballast water exchange. Ports are also increasingly engaging with local communities to mitigate concerns over port-related noise and traffic, and other local community concerns.

Commercial marine shipping has a global environmental impact by contributing to climate change through GHG emissions. In Canada, marine shipping produced 6.7 megatonnes (Mt) of GHG emissions in 2013, accounting for 8% of the commercial transportation total, or about 1% of total Canadian GHG emissions. Marine shipping remains the least GHG emission-intensive mode of commercial transportation. The emission intensity (i.e., GHG emissions per tonne-km) of the global industry will likely continue to decline as vessels become more efficient and use lower-carbon fuels.

Security Impacts

Illegal drugs and counterfeit goods enter Canada by all modes of transportation including by ship. Since 2005, Canadian ports have become more involved in both the export of domestically manufactured synthetic drugs to markets abroad and the import of high-potency synthetic drugs and precursor chemical shipments for domestic production. While the precise volume of contraband flowing through Canadian ports is unknown, some of the largest cases of smuggling investigated by Canadian authorities have involved marine ports.

To the extent that the Northwest Passage opens the door to increased shipping activity as ice melts, Canada's assertion that the Northwest Passage lies within its territorial waters may be increasingly challenged. Increased marine shipping in the Arctic, Canadian or otherwise, may have implications for Canadian sovereignty.

Individuals employed in the marine shipping industry experience direct risks to their personal health and safety through occupational hazards. In Canada, cargo vessels were involved in 8 fatalities and 68 on-board accidents involving serious injuries between 2011 and 2015. However, fishing, ferry, and passenger vessels account for the large majority of marine accidents aboard ship. Hazardous materials stored on ships or in port facilities can threaten the safety of workers. Incidents involving improper handling or storage of these materials have led to accidents and worker fatalities internationally. Infrastructure at or near ports could be a potential target for a terrorist attack.

THE VALUE OF COMMERCIAL MARINE SHIPPING TO CANADA

Despite other competing modes of commercial transportation, including road, rail, and air, marine shipping remains a vital part of Canada's economy, culture, environment, and security. Overall, in the Panel's view, the net national value of marine shipping to Canada is positive and widely distributed across the country. This is not to suggest that all the impacts of marine shipping are positive; rather, by facilitating international trade, marine shipping provides overall positive value. The national economic impact of marine shipping, arising from its role in facilitating international trade, is equal to approximately 1.8% of the Canadian economy, or about $30 billion. Although negative impacts on the environment and security are in some cases sizable, marine shipping produces only 1% of GHG emissions in Canada. Marine shipping is an important part of Canada's culture and Arctic sovereignty despite concerns about its impact on culturally important ecological areas and ways of life.

At the regional and local levels, commercial marine shipping also has both positive and negative impacts on the economy, culture, environment, and security. These impacts vary in severity by location and are often associated with non-market externalities that are difficult to monetize. The evidence did not allow for a definitive assessment of the net regional and local value of commercial marine shipping across Canada. However, while many of the economic benefits of trade facilitated by shipping are broadly dispersed, most negative environmental, security, and cultural impacts tend be concentrated locally.

Marine shipping is more than just a conduit for connecting Canadians to the world outside of North America. For some types of goods, there is no viable alternative to getting them to market or receiving them from abroad. This collective enterprise plays a central role in Canada's collective social well-being. The evidence bears this out. When assessed in totality and from all angles — considering economic, environmental, security, and cultural impacts at the national, regional, and local levels — the net overall value of marine shipping to Canada is positive and sizable.

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1

Introduction

- Charge to the Panel
- Panel's Approach
- Scope of the Assessment
- Structure of the Report

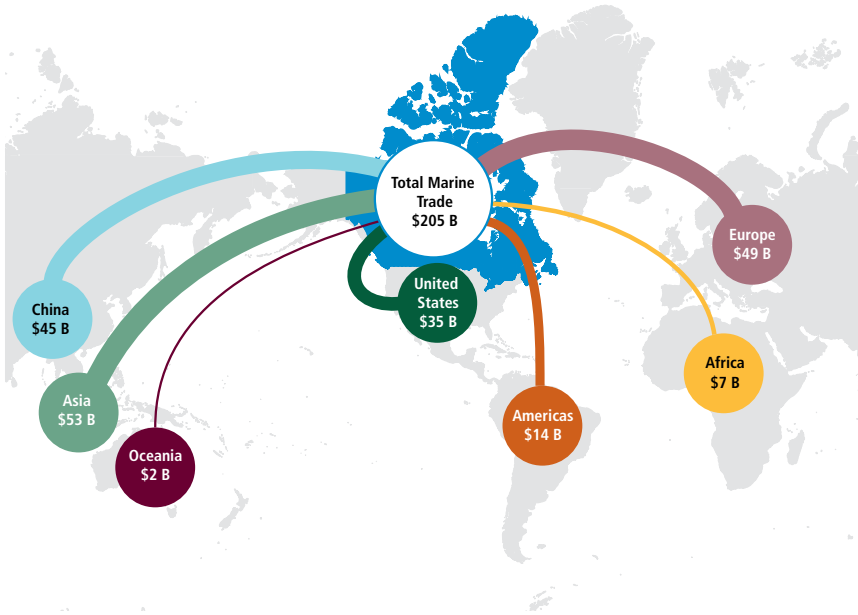
1 Introduction

Consider a typical day in the life of a wheat farmer in Saskatchewan as the harvest approaches. A smartphone is consulted over morning coffee and breakfast after it uploads the latest data from sensors in the wheat fields monitoring moisture levels and barometric trends. A replacement part for the combine must be picked up at a local distributor. Contracts have to be arranged for upcoming shipments, which will eventually carry her crop from its origin in the Prairies to countries in Europe and Asia. And then there are daily domestic chores to complete. A trip to the grocery store is in order and new clothes for the school year need to be purchased. A final obligation is a stop at a retail store to pick up a new bicycle for her son with a birthday at the end of the week.

At first glance, this all seems far removed from the marine environment. Deep in the interior of North America and over 1,000 kilometres (km) from the coast, there are certainly no ports or oceangoing ships nearby. There are no visible reminders of the extensive coastlines that constitute the borders of the three sides of Canada's vast landmass, aside from the occasional sea gull. However, the absence of these signs is misleading. The reality is that marine shipping touches virtually every part of this farmer's day. Most obviously, she depends on ships to get her crops to market. Well over half of the grain she harvests will eventually be transported by ship to markets overseas. Without the market access that these ships provide, the financial viability of the farm would be in question.

Marine shipping affects this wheat farmer in numerous other ways. The coffee maker, purchased at a local retailer, most likely arrived on a container ship, perhaps in Vancouver or Montréal. The smartphone that monitors growing conditions was assembled at a plant in China, with components sourced and likely shipped from countries around the world. The combine part was ordered from a supplier in South Korea and delivered through a network of marine shipping and trucking. At the grocery store, the selection of goods (and their low prices) reflects the fact that many of them came from overseas on ships. New clothes for the school year are more affordable because most were imported in large volumes by ship. Finally, the bicycle, like many consumer goods sold by the retail store, arrived in Canada in a shipping container. Its price reflects the efficiencies and economies of scale that the retailer can achieve by accessing foreign manufacturers and suppliers, and exercising market power in global sourcing negotiations.

In all these ways, marine shipping has a nearly universal presence in the lives of Canadians. It is integral to the movement of goods in and out of the country and to the economic choices that consumers and businesses make every day. For commodity producers, marine shipping provides reliable and cost-effective access to global markets, enabling economies of scale and higher levels of productivity. For consumers, it allows access to the vast array of goods sourced from around the world and available on retail shelves across Canada. In 2015, Canada's international marine trade was valued at $205 billion, with about 80% outside of North America (Statistics Canada, 2015) (see Figure 1.1). For Canada's island and northern communities, marine shipping is often the only source of essential goods and supplies. However, for all that marine shipping touches on so many facets of Canadian life, a comprehensive account of its value, both positive and negative, to Canada does not exist.



Data Source: Statistics Canada, 2015

Figure 1.1

Canada's Major International Marine Trade Flows, 2015

The figure presents an overview of Canada's major international trade flows in 2015. The dollar value indicates total marine trade (i.e., sum of marine exports and imports) between Canada and China, United States, and five continents.

1.1 CHARGE TO THE PANEL

Given the need for a comprehensive account of the value of marine shipping to Canada, Clear Seas Centre for Responsible Marine Shipping (Clear Seas) asked the Council of Canadian Academies (CCA) to undertake an expert panel assessment. Specifically, Clear Seas asked the following questions:

> *What is the social and economic value of commercial marine shipping to Canada and its regions? How will global trends related to shipping affect future shipping activity in Canada?*

To address the charge, the CCA assembled a multidisciplinary and multisectoral panel of 10 experts (the Panel) from Canada and abroad. The Panel's composition reflected a balance of expertise, experience, and demonstrated leadership in areas relevant to marine shipping. Each member served as an informed individual rather than as a representative of a particular discipline, sector, or region. For more than a year, the Panel reviewed, analyzed, and interpreted the best available evidence on marine shipping and its value, including a review of both academic and grey literature and original data analysis. This report is also the result of the Panel's in-person deliberations on the evidence.

Before turning to a discussion of how the Panel came to understand and define value, it is important to define *commercial marine shipping*. For the purpose of this report, it includes all shipping, domestic or international, involved in the transportation of commercial goods on navigable bodies of water. This includes bulk, breakbulk, and container shipping, and excludes cruise ships and passenger-only ferries.

This assessment is a separate, but complementary, follow-on project to the CCA workshop report, *Commercial Marine Shipping Accidents: Understanding the Risks in Canada* (CCA, 2016), which provided an assessment of marine accident risks and impacts that are not associated with normal operation (see Box 5.3). This report follows the categorization of Canada's regions used in CCA (2016): Western Canada (British Columbia and Alberta); the Prairies (Saskatchewan and Manitoba); Central Canada (Quebec and Ontario); Atlantic Canada (New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador); and Northern Canada (including the Arctic and the three territories).

1.2 PANEL'S APPROACH

Commercial marine shipping undoubtedly has value to a maritime nation such as Canada. This value comes in different forms, both positive and negative, and ranges from economic to cultural to environmental. As the report reveals, the geographic distribution of this value can often be uneven. Coastal areas and port cities typically experience more acute concentrations of impacts than do inland regions, whose agriculture and natural resource producers are particularly dependent on marine shipping to move large volumes of goods to markets outside of North America. In short, the value of commercial marine shipping to Canada is significant, complex, and unequally distributed. No single estimate or perspective can comprehensively account for it.

Given these challenges, the Panel considered the many ways in which marine shipping has an impact on Canadians. It also examined the different methods of assessing value and the assumptions that underlie these methods. Existing studies of marine shipping value are frequently contentious, with conflicting findings often rooted in different definitions (i.e., what constitutes value and for whom) and different methods (e.g., economic impact analysis, case studies). For these reasons, the Panel cast a wide net when identifying evidence relevant to its charge.

Panel members also recognized that individuals' own *values* — the moral precepts that inform understandings of the world — influence in part how they understand and assess the *value* of an activity like marine shipping. This adds to the challenge of assessing value because current beliefs about the impacts of shipping in Canada are governed by competing value systems, including whose values are at stake — those of industry, government, or citizens — and how best to account for them. The value of marine shipping is not uniformly perceived by stakeholders since their unique values determine the relative importance that they place on the various impacts. For example, industry, which includes both the marine shipping industry itself and other industries that use marine shipping services (e.g., oil, retail), may assign more weight to the economic impacts of marine shipping while still remaining concerned about its environmental impacts. While governments at all levels place weight on economic and environmental impacts, they must also balance security, cultural, and other impacts, as defined

by Section 5 of the *Canada Transportation Act* (Government of Canada, 1996).[1] Citizens, including private individuals or members of civil society groups, are even more likely to have divergent values and thus weigh the types of impact differently than industry or government.

In defining *value*, the Panel determined that strictly dividing the social value and the economic value was unhelpful in responding to its charge. This follows from an established premise that an economic system can be considered part of the wider social system and in parallel with other systems (e.g., political, legal, cultural).[2] Ultimately, an economic activity such as commercial marine shipping is "embedded" in the social system or at least heavily influenced by social networks (Jackson, 2008), social norms (Gintis *et al.*, 2005), social institutions (Ostrom, 2005), or social orders (Harari, 2014).

This premise led the Panel to define social value as comprised of four dimensions: economic, cultural, environmental, and security (Figure 1.2). In its examination of each dimension, the Panel sought to incorporate indicators where possible. It is generally recognized that the economic dimension of value can be more easily assessed with indicators than the cultural dimension, for example. However, even for the economic dimension, some indicators do not exist (e.g., cargo tonne-km by origin and destination) or no longer exist (e.g., volume of marine trade by port and region). Table 1.1 lists the indicators considered, some of which are critical to the evidence base that is developed in this report.

1 The Act is the federal framework for Canada's transportation system and for the Canadian Transportation Agency's role (CTAR, 2015a). Section 5 declares "that a competitive, economic and efficient national transportation system that meets the highest practicable safety and security standards and contributes to a sustainable environment and makes the best use of all modes of transportation at the lowest total cost is essential to serve the needs of its users, advance the well-being of Canadians and enable competitiveness and economic growth in both urban and rural areas throughout Canada" (Government of Canada, 1996). The Act was reviewed by an expert panel in 2015 (CTAR, 2015a, 2015b).

2 An economic system, the production and distribution of goods and services, is part of a social system. It is "organized by a set of rules, among which are allocation by fiat in states, firms, and other organizations, patriarchal and other customary allocations based on gender, age, and kinship, gift, theft, bargaining, and of course markets. Particular combinations of these rules give entire societies modifiers such as 'capitalist,' 'traditional,' 'communist,' 'patriarchal,' and 'corporatist'" (Bowles, 1998).

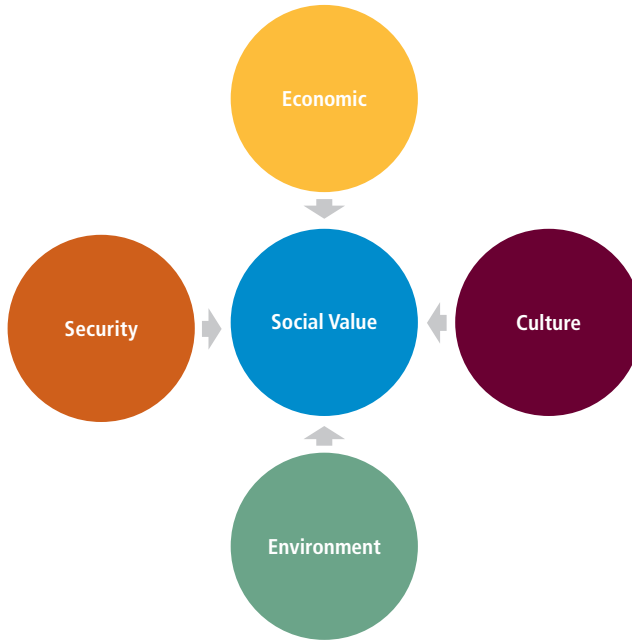


Figure 1.2

Dimensions of Social Value of Commercial Marine Shipping

The figure highlights the multidimensional nature of the social value of commercial marine shipping. The Panel used this framework to comprehensively assess social value and to reflect a plurality of values. The circles are intentionally the same size to avoid ascribing a particular value system to the Panel's assessment. Stakeholders and other readers of this report can assign their own weights to the various dimensions of social value.

Table 1.1

Indicators Considered in Assessment of Social Value

Dimensions of Value	Existing Indicators	Possible New Indicators
Economic	• Marine exports by volume (up to 2011) and dollar value • Marine imports by volume (up to 2011) and dollar value • GDP of marine shipping industry • Employment in marine shipping industry • GDP facilitated by international marine trade • Commodity production and marine trade by region	• Marine exports by volume (since 2011) • Marine imports by volume (since 2011) • Cargo tonne-km by original and final origin and destination • Employment by Canadian port
Culture	• Marine shipping symbols • Beliefs about Canadian marine shipping • Number and type of marine imports	• Employment-related identity • Impacts on Indigenous peoples • Community well-being index • Marine services well-being index • National system for the identification of significant marine cultural sites
Environment	• Total greenhouse gas (GHG) emissions by mode of transportation • Total criteria air contaminants by mode of transportation • Number of invasive species introduced by marine ships • Number of whale strikes • Frequency of spills • Average size of spills	• Criteria air contaminants in port cities • Ambient noise by cargo mode • Traffic congestion related to marine cargo in port cities
Security	• Worker injuries and fatalities per year in port-related employment	• Worker injuries and fatalities per millions of tonnes of cargo moved by mode • Dollar value of drugs seized at ports • Dollar value of counterfeit goods seized at ports • Number of icebreakers and military and research vessels in Arctic Canada

The table presents a non-exhaustive list of indicators and other measurements collected, reviewed, and analyzed by the Panel during its deliberations. In general, the existing indicators are collected by various agencies or government bodies, but there is not a "single window" reporting mechanism. They may be collected irregularly and inconsistently. Data limitations, and time availability, prevented the Panel from collecting all relevant evidence needed to comprehensively assess the value of marine shipping. The rightmost column provides a non-exhaustive list of indicators and measurements that could be collected and reported, respectively.

For the economic dimension, the Panel sought to assess the value associated with the marine shipping industry itself as well as the value that stems from the marine trade that it facilitates. To this end, the Panel commissioned a quantitative trade model to assess the role of marine shipping in the broader economy. The model represents the state of the art in general equilibrium trade modelling, incorporating insights from both international trade and transportation economics. It extends the model in Caliendo and Parro (2015), which accounts for specialization and trade patterns, by incorporating different modes of transportation in an economically meaningful and analytically tractable way. This approach makes a novel contribution to understanding the value of commercial marine shipping.

A national quantitative estimate of the economic impact of marine shipping, however, hides important dimensions of value. There is little academic and grey literature on many of these areas. To address this lack of evidence, the Panel complemented its literature review with a series of case studies, exploring the diverse roles that marine shipping plays in Canada's marine trade, port communities, and regions. Specifically, the Panel developed case studies of commodities (crude oil; wheat and canola), industries (advanced manufacturing, retail), and port communities (Prince Rupert, Montréal, Come By Chance, Iqaluit) to inform its analysis.[3]

1.3 SCOPE OF THE ASSESSMENT

Commercial marine shipping has multidimensional value. Since much of this value arises in relation to its role as a mode of transportation in trade, marine shipping is often associated with issues arising from trade more generally (using all modes). In the Panel's view, however, these issues cannot be fully attributed to marine shipping.

As a positive value, both economic theory and empirical evidence suggest that trade benefits nations in aggregate (Ricardo, 1817; Gopinath *et al.*, 2014; Caliendo & Parro, 2015). Trade fosters specialization and improves productivity by allowing nations to economically focus on the industries and activities in which they have a comparative advantage. Trade benefits exporters by opening up new markets, importers by providing access to lower-cost suppliers, and consumers by providing access to a greater variety of goods at a lower cost. The country and economy as a whole benefit as a result. These economic benefits are a component of social value, primarily and in so far as they translate to tangible and measurable improvements in well-being.

3 The case studies are neither included in full nor published separately. Rather, what the Panel learned from them is incorporated into this report.

As with the value of marine shipping, the costs of trade are not equally distributed. Recent debates over free trade agreements have highlighted that trade is often accompanied by threats to individuals, industries, and regions. Trade can lead to the offshoring of jobs, as companies shift production to minimize their costs; it also allows companies to specialize within complex global production networks and gain value from economies of scale in production. Where this occurs, foreign workers benefit but the domestic economic dislocation can be substantial and long-lasting as alternative sources of economic activity (or compensatory public policies) may be slow to materialize (Autor *et al.*, 2016). The resulting shifts in the labour market from trade may benefit the highly skilled at the expense of less-skilled workers (Krugman *et al.*, 2015). There are also concerns that trade allows firms to relocate operations to jurisdictions with less stringent environmental and labour standards (Bhagwati, 1995; Rodrik, 1997; Frankel & Rose, 2002; Stiglitz, 2002). Others argue that trade agreements may erode national sovereignty by forcing nations to adopt regulatory standards or policies that would otherwise be publicly unacceptable, or that trade with certain countries is not consistent with national values or geopolitical interests. Inevitably, trade is implicated in sweeping debates about globalization, the environment, and social justice.

To the extent that marine shipping is integral to international trade and globalization in its current form, debates about shipping bring these concerns and criticisms to the fore. However, such issues are larger than marine shipping. They apply to trade in general, which involves all modes of freight transportation, and are embedded in broader national and international debates on social, economic, environmental, and other policies. Overall, the Panel is largely persuaded by the theory and evidence that trade normally increases the wealth of trading partners, but those gains are distributed unevenly within countries. The Panel recognizes that the distribution of trade gains and losses among individuals, industries, and regions is a source of political controversy. It is a crucial issue for governments, at all levels, that hold a range of public policy levers on labour mobility, income redistribution, environmental stewardship, regional economic development, and other factors. Such public policy choices are beyond the scope of the Panel's charge.

A number of global social forces are likely to have an effect on shipping activity: population and income growth, global trading behaviour, technological progress, energy production, and climate change. However, commercial marine shipping does not drive these forces, but rather responds to them. The direction and size of these forces shape the type of society in which trade and its impacts exist. An assessment of their causes and consequences is also beyond the scope of the Panel's charge: to comprehensively assess the value of marine shipping to Canada.

1.4 STRUCTURE OF THE REPORT

The report is structured as follows. **Chapter 2** describes the context for marine shipping in Canada. It discusses its relevance to early Indigenous and colonial trade, provides an overview of today's shipping industry, and describes its role in domestic and international trade. **Chapter 3** illustrates the role of marine shipping through case studies on Canada's coal, wheat, oil, and advanced manufacturing industries. It also discusses annual resupply in the Arctic. **Chapter 4** assesses the four dimensions of value from a national perspective. This includes an estimate of national economic impact from the Panel's quantitative trade model as well as evidence drawn from a variety of sources on cultural, environmental, and security impacts. **Chapter 5** then discusses the distribution of the multidimensional value of commercial marine shipping across the country. This takes into account regional and localized impacts associated with shipping and ports. As commercial marine shipping activity is dynamic, **Chapter 6** consequently considers how specific trends in global social forces may affect shipping in the future. **Chapter 7** summarizes the Panel's main findings and conclusions.

2

Overview of Marine Shipping and Trade in Canada

- Role of Shipping in Canadian History
- Canada's Marine Shipping Industry
- Canada's Domestic Marine Trade
- Canada's International Marine Trade
- Concluding Remarks

2 Overview of Marine Shipping and Trade in Canada

Key Messages

- Indigenous peoples engaged in marine trade for millennia before European settlement, and their long-standing routes shaped early colonial trade and port development.
- The marine export of fur, fish, and timber was central to early Canadian economic growth, environmental decline, and cultural loss.
- Domestic marine trade is widely but unevenly distributed across the country. Most of this trade is in a small number of bulk commodities such as forest products, iron ore, and crude oil.
- Marine shipping carries essential bulk commodities and general cargo to island, remote, and northern communities in Canada.
- Marine shipping transports 20% of Canadian exports and imports by value. This share has been stable since 2006.
- In 2015, marine trade was valued at $205 billion. About 80% of this trade is with countries outside North America.
- Canada differs from most countries in that it both exports and imports large volumes of the same bulk commodities, including oil, coal, and iron ore. This reflects geographic size and related transportation costs.
- Canada imports a diverse range of general cargo, including consumer goods, machinery and equipment, and intermediate imports, most of which is containerized. This is similar to other developed countries, reflecting integrated global supply chains.

Marine trade has been a part of Canada for millennia, beginning with the Indigenous peoples. Since that time, commercial marine shipping and the maritime tradition have played a historically significant role in the economic, environmental, and cultural development of Canada. Today, marine shipping is essential to international trade, carrying more than $200 billion of goods to and from global markets annually (Statistics Canada, 2015). This chapter provides a foundation for understanding the overall value of marine shipping to Canada.

2.1 ROLE OF SHIPPING IN CANADIAN HISTORY

Canada has been shaped by its history as a coastal nation through a combination of geography and design. With coasts stretching 243,792 kilometres along the Atlantic, Arctic, and Pacific oceans, Canada has the longest national coastline in the world. Its borders include the major inland seas of Hudson Bay, James Bay, the Strait of Georgia, and the Gulf of St. Lawrence (DFO, 2008). The Atlantic and

Pacific oceans that define Canada's borders provide valuable natural resources and a key transportation conduit connecting Canada to other nations. Canada is home to large ports and port cities, including Vancouver, Prince Rupert, Thunder Bay, Montréal, Halifax, Saint John, and St. John's. It also features an extensive network of inland waterways including the Great Lakes, which connect inland North America to the Atlantic Ocean through the St. Lawrence River. By Canadian waterway, it is possible to travel from tidewater near Quebec to the coast in Canada's western Arctic and to the Pacific coast (Legget, 2015). Such waterways played an important historical role in the European settlement and colonization of Canada. Today, these waterways are a central element of Canada's national transportation system (CTAR, 2015a).

2.1.1 Long-standing Indigenous marine trade routes shaped early colonial trade and port development.

Indigenous peoples have lived in Canada for 10 to 15 millennia (Pederson *et al.*, 2016), developing many diverse communities, each with its own complex culture and social structure (Moore, 1993). Economically, while these groups predominantly relied on hunting-gathering and horticultural food production systems (Deur & Turner, 2005), they also established and maintained regional economic systems that engaged in long-range trade across many cultural and linguistic boundaries. Many of these trade routes traversed inland and coastal waterways and were navigated with canoes, kayaks, and umiaks. For example, via canoe on inland waterways, the Haida of northern British Columbia traded fish and shell ornaments to the Tsimshian for blankets and hides, and to the Tlingit for eulachons and soapberries (Fisher, 1992). The Barter Island Inuit used skin boats to trade dried salmon for caribou hide with the Kutchin (Gwich'in) (Coates, 1982; Adney & Chapelle, 2014).

When Europeans began to trade on the outer fringes of Indigenous trading networks, they dramatically altered the extent and content of the exchange (Moore, 1993; Innis, 1999; Miller, 2009). To facilitate trade of recently available European commodities (e.g., cloth, guns, iron kettles, copper knives), early colonial settlers relied upon the location of Indigenous communities along trade routes, alliances with Indigenous peoples, and Indigenous knowledge (Carlos & Lewis, 2010). The maintenance of long-established trading relationships no longer depended upon surplus and traditional importance, but on the availability and cost of the desired goods (Moore, 1993). This shift eventually led to the fur trade, which relied on inland communities and waterways, and the commercial fishery on Canada's East Coast, which relied on coastal communities (Innis, 1999; Carlos & Lewis, 2010). In this sense, the existence of established Indigenous communities, in addition to natural history, shaped the creation of large ports in Canada by Europeans.

2.1.2 The export of fur, fish, and timber by ship was central to early Canadian economic growth, environmental decline, and cultural loss.

Marine transportation was the only way to import European commodities, such as cloth, guns, tools, and luxuries, to Canada (Diamond, 1997; Morton, 2006). Equally, it was the only way to export large volumes of Canadian staples, such as fish, timber, and fur, to Europe (Mackintosh, 1923; Innis, 1930). Canada was also a major supplier of timber, including naval masts, for Britain. The timber trade fostered investment and immigration to North American colonies (Wynne, 2015). Trans-oceanic voyages and inland water transport were also critical to the development of the fur trade, which played a major role in the historical settlement and development of Canada (Eccles & Foster, 2015). European demand for beaver pelts in the 18th and 19th centuries drove intense commercial competition and exploration, and fuelled the activities of French-Canadian trappers as well as the British Hudson's Bay Company (Carlos & Lewis, 2010). The economic activity that resulted from the extraction and export of fish, timber, and fur to Europe was central to Canada's early economic growth (Watkins, 1963) and political development (Easterbrook & Watkins, 1984). It was equally as central to the over-fishing, forest degradation, and biodiversity loss that resulted (Zilberstein, 2016).

Several major cities owe their location and development to their status as transit points for marine shipping. Montréal, for example, was settled due to its location next to the Lachine rapids on the St. Lawrence, the first major barrier faced as ships navigated upriver from the Atlantic and Gulf of St. Lawrence (see Box 2.1). Early European settlements were also often founded near existing Indigenous settlements, created to take advantage of the geographic characteristics that made these locations central transit points for the surrounding region (Innis, 1999; Miller, 2009). However, the influence of European trade was not always benign, particularly for Indigenous peoples (Harari, 2014). By enabling the colonization of North America, marine shipping disrupted and displaced Indigenous transportation and trade networks. It also became a means for the introduction of European diseases and conflicts to the continent, leading to widespread depopulation and corresponding cultural losses (Daschuk, 2013).

Box 2.1
Shipping, Trade, and the Historical Development of Montréal

Montréal owes its location largely to its strategic importance in facilitating water-borne trade. The initial settlement was a transhipment point for goods travelling up and down the St. Lawrence, serving mainly canoes, flatboats, and barges (Linteau, 2015). Goods to be portaged around the Lachine rapids were transferred into smaller or larger craft, depending on the direction of travel (Morse, 1969). While Québec City was the primary departure and arrival point for transatlantic voyages, Montréal's strategic location at the confluence of major inland waterways (along with its proximity to Indigenous peoples) made it the centre of the expanding fur trade in the 17th and 18th centuries. This gave the city a prominent role in Canada's economic and historical development (Linteau, 2015).

Montréal's role in supporting trade has evolved, in response to technological, economic, and social changes. Improvements to the St. Lawrence waterway (both up and down river of Montréal) gradually expanded and changed the role of the port. These included the development of the Lachine Canal, progressive episodes of dredging the St. Lawrence, and the eventual completion of the St. Lawrence Seaway in 1959. The adoption of steamships in the 19th century allowed oceangoing vessels to economically travel up river, obviating the need to stop at Québec City and dramatically increasing Montréal's importance to international trade (MacKinnon, 2003). By 1910, successive rounds of dredging had deepened the main channel to a depth of 10.7 metres, allowing larger vessels to reach the port (Kaczkowski & Shaw, 2015). In the late 1960s, the federal government committed to using icebreakers to keep the main channel navigable throughout the year, increasing the port's attractiveness as a gateway for transatlantic trade (Guy & Alix, 2007).

2.1.3 The historical importance of marine shipping is reflected in Canadian cultural symbols.

Canada's status as a maritime trading nation is enshrined in cultural symbols that relate to marine shipping (Figure 2.1). The canoe has an unofficial status as a Canadian symbol. The birch bark canoes used by Indigenous peoples in Eastern Canada were subsequently adopted as a principal means of transportation for the fur trade. *Voyageurs*, also a fixture in the cultural memory of Canada, are associated with "the romantic image of men [sic] canoeing across the continent in search of furs and living a life full of perilous adventure, gruelling work and cheerful camaraderie" (Gousse & Foster, 2015). The cultural significance of *Voyageurs* continues to be celebrated in events and festivals such as the annual *Festival du Voyageur* in Winnipeg and the *Rendez-vous des coureurs des bois de Trois-Rivières* (Gousse & Foster, 2015).

Voyageurs: Copyright: Library and Archives Canada, ACC. No. 1989-401-1; Amundsen: Bank of Canada, 2017

Figure 2.1

Canadian Cultural Symbols Related to Maritime Shipping and Trade

Left: Voyageurs paddling a canoe (*Quetico Superior Route, Passing a Waterfall* by Frances Anne Hopkins). Right: 50¢ "Bluenose" Stamp of 1929. Bottom: Canadian $50 bill with a picture of the CCGS *Amundsen*.

Other national symbols are associated with marine environments. Nova Scotia fishing and racing schooner *Bluenose* is currently engraved on the Canadian dime and has been featured on postage stamps in the past. Nicknamed "Queen of the North Atlantic," the schooner represented Nova Scotia and Canada in events around the world including the 1933 A Century of Progress International Exposition (Chicago's World Fair) and the 1935 Silver Jubilee of King George V (Marsh, 2016). Previously known as the Canadian Coast Guard Ship (CCGS) *Sir John Franklin,* the CCGS *Amundsen* became a research icebreaker in 2003 after a refurbishing by a consortium of universities and government agencies (Bank of Canada, 2017). It has a range of 15,000 nautical miles and is equipped with a "moon pool" that gives access through the bottom of the ship, enabling researchers to deploy scientific instruments into the Arctic Ocean even when surrounded by thick ice. It is operated jointly by the Canadian Coast Guard and ArcticNet (Bank of Canada, 2017).

Canada's economic dependence on commercial marine shipping may have become less readily apparent over time, but these symbols are a reminder of its formative role in Canada's history.

2.2 CANADA'S MARINE SHIPPING INDUSTRY

In 2015, the world's commercial fleet consisted of approximately 90,000 vessels, with a total tonnage of 1.75 billion deadweight tonnes (dwt)[4] (UNCTAD, 2015). Greece is the largest ship-owning country, accounting for approximately 16% of the world total. Citizens of Greece, Japan, China, Germany, and Singapore together own more than half of world tonnage. Canadians own about 0.5% of vessels by tonnage and are ranked 32nd on the ownership list. More than 50% of vessels (by dwt) are, however, registered in one of four countries — Panama, Liberia, Marshall Islands, or Hong Kong — for tax or other corporate reasons (UNCTAD, 2015). The Canadian flag is not competitive internationally, but Canada does provide favourable conditions for the location of international ship management companies.

The majority of shipping activity is in four groups: dry bulk (43.5% of total deadweight capacity), tankers (28%), container (13%), and general cargo (4.4%) (UNCTAD, 2015).[5] The dry bulk and tanker business consists of the unscheduled carriage of dry and liquid bulk commodities (e.g., wheat, crude oil) for one or few firms (Brooks, 2011; Heaver, 2015). This market is characterized by highly volatile freight rates and is very competitive although capital costs are high and sunk (Brooks, 2011). Container cargo shipping, by contrast, consists of transporting cargo in truck-size intermodal containers for many firms on a regular schedule (Brooks, 2011; Heaver, 2015). This has evolved into a global container market with a current oversupply of capacity and limited differentiation. The recent poor economic returns have led to fewer companies (UNCTAD, 2015), more consolidation (Sys, 2009), and historically less volatile freight rates than the bulk markets (Brooks, 2011).

Canadian export and import industries rely almost exclusively on foreign-flag vessels for non-U.S. marine-based trade because Canada has few national carriers and a small global presence (CTAR, 2015a). In 2011, Canadian-flag vessels carried only 0.1% of marine exports and imports (Statistics Canada, 2012; Transport Canada, 2015b). A few Canadian-based companies, such as Canadian Steamship Lines and Fednav Ltd., are active in Canada's international trade using foreign-flag vessels (Transport Canada, 2015b). Canada is also home to ship-owning firms such as Seaspan, the world's largest independent owner of container ships operated for major lines; Teekay, a major carrier in the oil and liquefied natural gas (LNG) trades; and Waterfront, the shipping subsidiary of

4 Deadweight tonnage is a measure of how much mass a ship can safely carry; it does not include the weight of the ship.

5 The remaining capacity, by dwt, consists of inland waterway vessels, fishing vessels, military vessels, yachts, and offshore mobile platforms and barges (UNCTAD, 2015).

Methanex. Canadian-flag vessels carry around 98% of domestic trade because of the *Coasting Trade Act,* which provides protection for the domestic industry (Brooks & Hodgson, 2005; Transport Canada, 2015a).

These vessels are also active in Canada–U.S.marine trade, valued at $216 billion over the 2006–2015 period (Statistics Canada, 2015; Transport Canada, 2015b). In 2014, the Canadian registered fleet consisted of 188 vessels with a total gross tonnage of 2.6 million gross tonnes (Transport Canada, 2015b). Dry bulk carriers accounted for 36% of vessels and 52% of gross tonnage, followed by tankers and general cargo vessels. In addition, an extensive fleet of 330 tugs and 1,120 barges operates in Canada, mainly on the Pacific coast (Transport Canada, 2015b). (Section 4.1.1 provides an overview and range of estimates on the economic impact, such as GDP, employment, of the Canadian marine shipping industry.)

While marine shipping is fundamentally an international activity, a ship is subject to the laws of the country in which it is registered (flagged) (Heaver, 2015). Canada has ratified most international shipping conventions and is active in ensuring the quality of ships serving Canadian trade through Transport Canada vessel inspections under the international provisions for port state control (found in the UN Convention on the Law of the Sea). The Task Force on Deep Sea Shipping concluded that Canadian exporters and importers were better off buying shipping services globally than supporting a national-flag, deep-sea shipping fleet through protectionist measures (Government of Canada, 1985; Brooks & Hodgson, 2005). Given the global nature of marine shipping and the low freight rates that Canadian businesses have enjoyed across all types of shipping, the Panel believes that Canadians have been served well by this policy over the last 30 years.

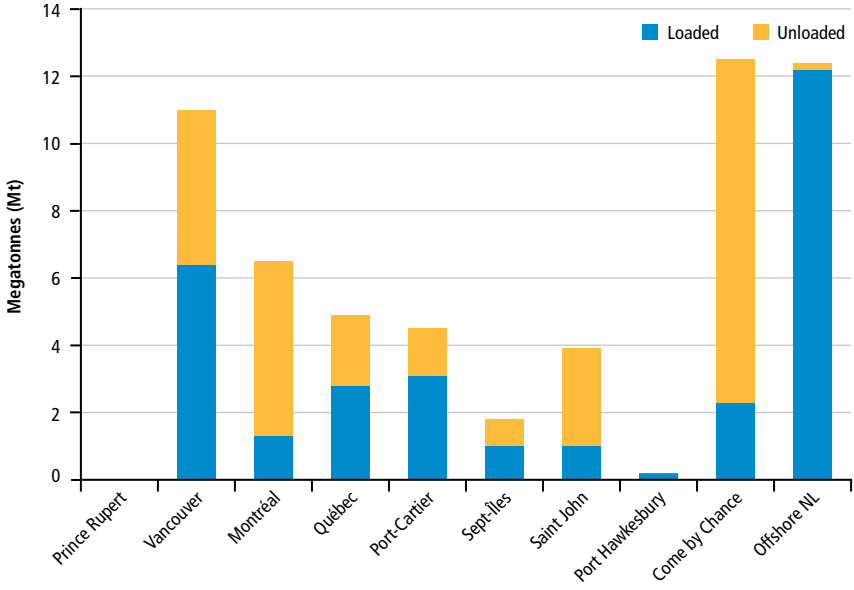
2.3 CANADA'S DOMESTIC MARINE TRADE

In 2011, Canada's ports and marine terminals handled 467 megatonnes (Mt) of cargo.[6] This comprised 342 Mt of international and 125 Mt of domestic cargo. Although domestic marine trade is considerably smaller, it is important for moving large volumes of commodities (e.g., forest products, iron ore, oil) across the country and virtually indispensable for island and northern communities in Canada.

6 The analysis in this section is based on a trade data set (Statistics Canada 2012) that includes statistics on marine trade *volume* by region and port for the 2002–2011 period. Commodity data are only presented by tonnes. Some analysis in Section 2.4 is also based on this data set.

2.3.1 Domestic marine trade is widely distributed across the country. Most of this trade is in a small number of bulk commodities such as forest products, iron ore, and crude oil.

Domestic marine shipping activity is concentrated in four areas of the country: British Columbia, Great Lakes and St. Lawrence, Atlantic Canada, and Northern Canada (CCA, 2016; Transport Canada, 2015). Figure 2.2 presents shipping volume in 2011 across Canada's 10 largest ports, which collectively cover approximately half of domestic marine trade.[7] By contrast, these 10 ports comprise more than 80% of Canada's international marine trade (Statistics Canada, 2012).



Data Source: Statistics Canada, 2012

Figure 2.2

Volume of Marine Domestic Trade by Canadian Port, 2011

The figure presents the volume of domestic marine trade (both loaded and unloaded) for Canada's 10 largest ports (by total marine trade) in 2011. Prince Rupert is exclusively focused on international trade.

7 In terms of container commodities, Vancouver is the sixth largest North America port trailing Los Angeles, Long Beach, New Jersey, Savannah, and Seattle (AAPA, 2015).

In British Columbia, Vancouver is the largest port for domestic marine trade, shipping 11 Mt of commodities in 2011, made up of 14 distinct types of goods, mostly forest products and minerals (e.g., limestone, stone/sand/gravel). In comparison, the port shipped 97 Mt and 54 types of goods in international marine trade. About an additional 10 Mt was shipped in the Strait of Georgia (East Vancouver Island, Howe Sound, and Crofton), but comparable data on commodities are not available. Although Prince Rupert is a key international port for coal and wheat export, it does not play a role in domestic marine trade (Statistics Canada, 2012).

In the Great Lakes and St. Lawrence, the ports of Montréal, Québec, Port-Cartier, and Sept-Îles accounted for about 31% of domestic marine trade in commodities such as iron ore, fuel oils, and wheat in 2011. These ports trade a wider variety of goods than Vancouver, especially Montréal, which traded sizable volumes of 21 distinct types of goods (still considerably fewer than the 54 types traded internationally) (Statistics Canada, 2012).

In Atlantic Canada, more than 27 Mt of crude oil was shipped between the ports of Saint John, Come By Chance, and Newfoundland offshore in 2011.[8] There was little domestic marine trade in Port Hawkesbury, which predominantly exports crude oil. Domestic marine trade in these ports was also limited to a small variety of goods (Statistics Canada, 2012).

2.3.2 Marine shipping carries essential bulk commodities and general cargo to island and northern communities in Canada.

Though Vancouver and Prince Rupert are directly connected to other modes of transportation in the Canadian transportation system (CTAR, 2015), Vancouver Island is limited to marine and air transportation for trade. In 2011, more than 7 Mt of goods[9] were transported by ship to the Island (Statistics Canada, 2012),[10] mainly by ferries (e.g., BC Ferries). This includes agricultural products, fuel oil, machinery and equipment (M&E), vehicles, and consumer goods. The island of Newfoundland is similar in this regard. In addition to 25 Mt of crude oil, an additional 5 Mt of goods were shipped there in 2011 (Statistics Canada, 2012). Much of this was shipped to St. John's and Corner Brook by short sea shipping (e.g., Oceanex) and then reshipped to smaller coastal communities (Transport Canada, 2006). Marine Atlantic ferries and Bay Ferries also supply ferry services in Atlantic Canada, carrying freight as well

8 These data include both tonnes loaded and unloaded. Some portion of 27 Mt is double counted. See Section 2.4.2 for more detail.

9 Panel approximation based on port data (Statistics Canada, 2012), which include East Vancouver Island, Crofton, Nanaimo, Beale Cove, and Port Alberni.

10 Bulk commodity and general cargo data are not available for the small communities discussed in this section. Examples of the goods shipped are inferred from Statistics Canada (2012) regional data.

as passengers. Without marine shipping, air would be the only available mode of transportation, on most of these routes. This would undoubtedly increase the price and decrease the variety of goods available in island communities.

Domestic marine trade in Northern Canada is only 300,000 tonnes per year (Statistics Canada, 2012), but is nonetheless a critical mode of transportation for food, fuel, construction materials, and other goods (Brooks & Frost, 2012; Statistics Canada, 2012). Given the high cost of transportation, the price of goods is also high, and there is less variety in the products available compared with other regions (CCA, 2014). As many of these goods are now essential to their survival, many Arctic communities have become dependent on marine shipping. This has significant social implications, which are discussed in more detail in Section 3.5.

2.4 CANADA'S INTERNATIONAL MARINE TRADE

Marine shipping has been important to the growth of international trade by helping to establish commercial relationships across widely separated countries and regions. While there is debate on the prominence of this role in the global trade boom of the 19th (Jacks & Pendakur, 2010) and 20th centuries (Bernhofen *et al.*, 2016), marine shipping is critical for transporting bulk commodities and container cargo.

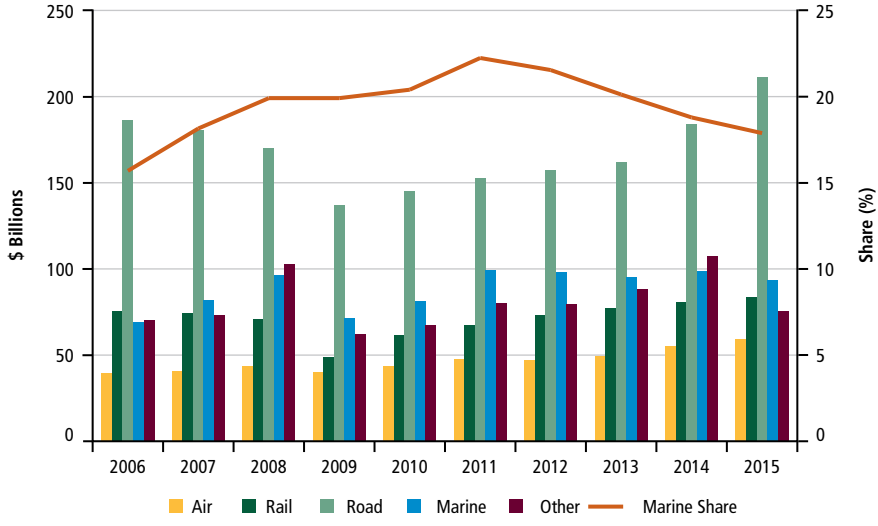
2.4.1 Marine shipping transports 20% of Canadian exports and imports by value. In 2015, marine trade was valued at $205 billion.

Over the 2006–2015 period, Canada's international marine trade totalled $1.9 trillion (Statistics Canada, 2015).[11] This amounts to about 20% of total international trade.[12] As Figures 2.3 and 2.4 illustrate, over this period, road was the most common mode of transportation. It accounted for 37% of exports and 53% of imports (Statistics Canada, 2015). The figures also highlight the stability of trade by mode of transportation.

In 2015, Canada's international marine trade totalled $205 billion, which included $93 billion of exports and $112 billion of imports. China ($45 billion) was Canada's largest marine shipping trading partner, followed closely by the United States ($35 billion) (Figure 2.5). Overall, about 80% of marine trade is with countries outside North America.

11 The analysis in this section is based on a trade data set (Statistics Canada, 2015) that includes statistics on trade *dollar value* ($C), location (country, province, and port), and transportation mode for the 2006–2015 period. The quantitative trade model in Chapter 4 is also partially based on this data set.

12 Specifically, 19.4% ($885 billion) and 21.9% ($973.4 billion) were exported and imported by ship, respectively, between 2006 and 2015.

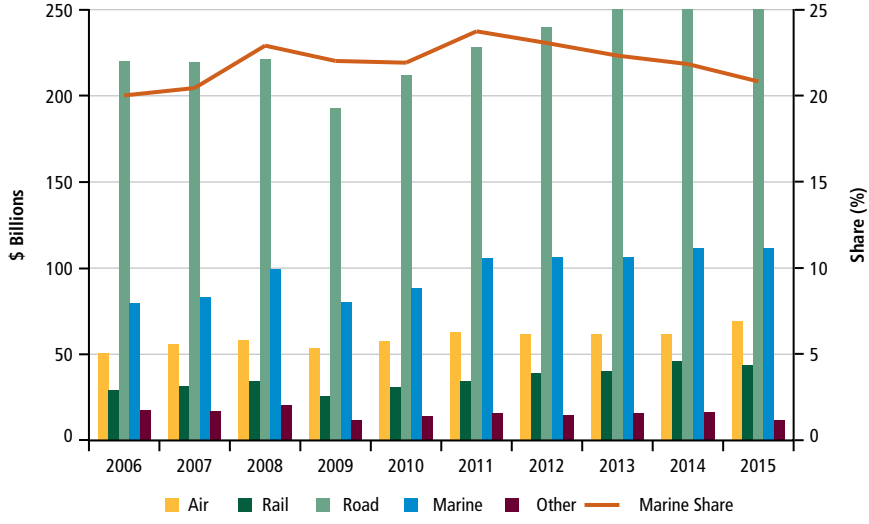


Data Source: Statistics Canada, 2015

Figure 2.3

Dollar Value of Exports by Mode of Transportation in Canada, 2006–2015

The figure presents the dollar value of exports by mode of transportation over the 2006–2015 period. The orange line plots the share of marine shipping.

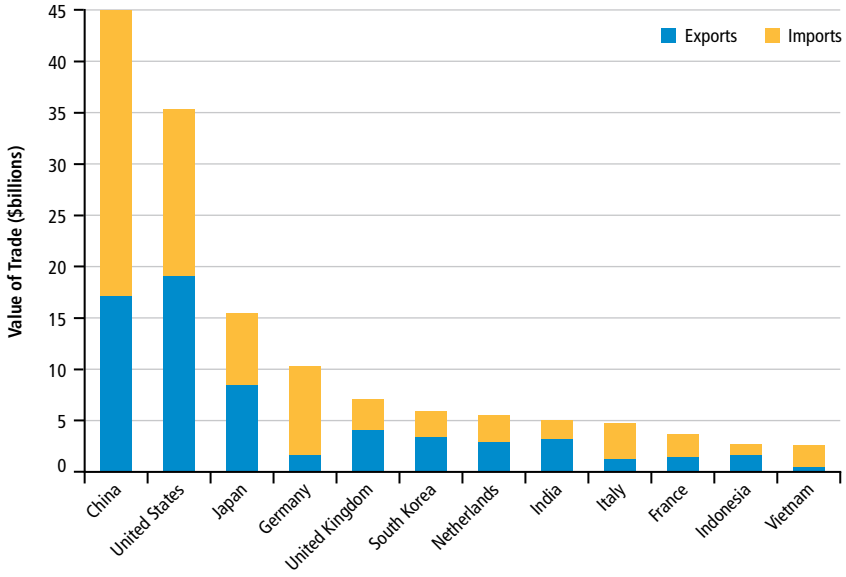


Data Source: Statistics Canada, 2015

Figure 2.4

Dollar Value of Imports by Mode of Transportation in Canada, 2006–2015

The figure presents the dollar value of imports by mode of transportation over the 2006–2015 period. The orange line plots the share of marine shipping.



Data Source: Statistics Canada, 2015

Figure 2.5

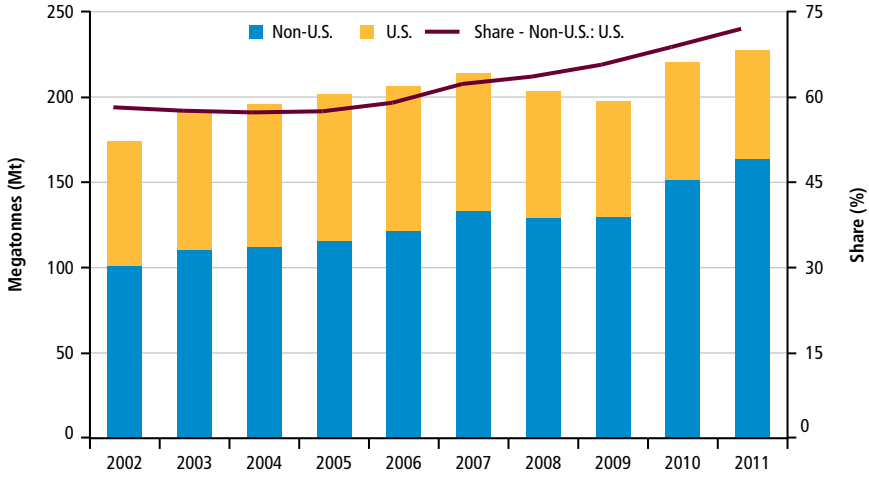
Value of Marine Trade with Canada by Country, 2015

The figure presents Canada's top 12 marine trading partners in 2015. This includes the sum of marine exports and imports.

2.4.2 More than 70% of Canada's marine trade, by volume, is with countries other than the United States. International marine trade is more than five times larger than domestic marine trade.

For many commodities, marine shipping is the only economically viable mode of transportation for trade outside of North America. Over the 2002–2011 period, Canada's marine exports grew by 2.7% per year, from approximately 174 to 227 Mt (Statistics Canada, 2003, 2012). By comparison, both the growth (0.6% per year) and 2011 amount of marine imports (114 Mt) are substantially slower and lower, respectively (Statistics Canada, 2012).

In 2011, approximately 72% of Canada's marine exports were destined for markets outside of North America, most significantly to Asia and Europe (Statistics Canada, 2012). Similarly, about 71% of marine imports originated from markets outside of North America, with Africa and Europe as the leading regions of origin. Figures 2.6 and 2.7 present non-U.S. and U.S marine exports and imports, respectively, for the 2002–2011 period. In both cases, the ratio of non-U.S. to U.S. marine exports (imports) rose steadily over the period (Statistics Canada, 2012).

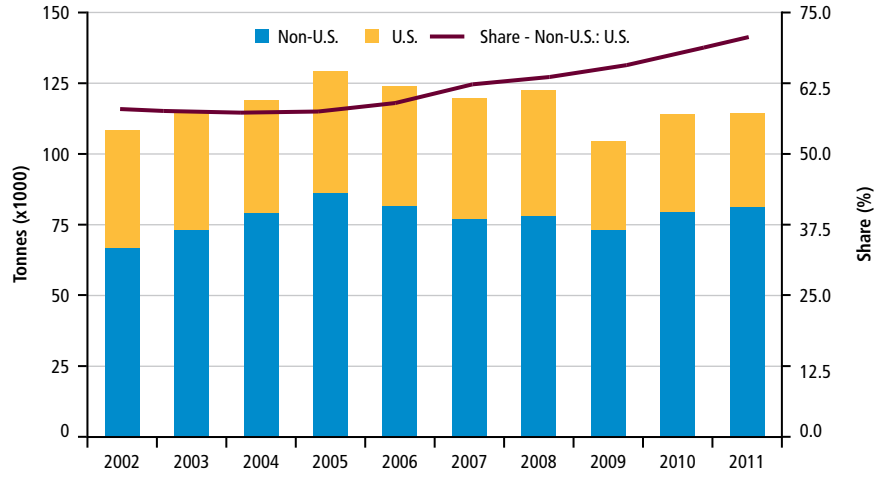


Data Source: Statistics Canada, 2012

Figure 2.6

Volume of Marine Exports in Canada, 2002–2011

The figure presents the volume of marine exports over the 2002–2011 period for U.S. and non-U.S. countries. The burgundy line plots share of marine exports to countries other than the United States.



Data Source: Statistics Canada, 2012

Figure 2.7

Volume of Marine Imports in Canada, 2002–2011

The figure presents the volume of marine imports over the 2002–2011 period for U.S. and non-U.S. countries. The burgundy line plots share of marine imports to countries other than the United States.

From an economic perspective, international marine trade is significantly (5.5 times) larger than domestic marine trade (341 versus 62 Mt).[13] The domestic marine shipping discussed in Section 2.3 consists of two-way shipments in the sense that they are both loaded (62 Mt) and unloaded (62 Mt) in Canada (Statistics Canada, 2012). When assessing national economic impact in Chapter 4, domestic cargo should be counted once. While the economic impact of shipping forest products from Vancouver or iron ore from Port-Cartier to destinations along the the B.C. coast and to Québec City, respectively, is positive, this impact should not be counted twice.[14]

2.4.3 Canada differs from most other countries in that it both exports and imports large volumes of the same bulk commodities. This reflects geographic size and related transportation costs.

Whether measured in tonnes or dollar value, the majority of marine exports are bulk commodities. By tonnes, the top marine export in 2011 was coal, followed by iron ore, crude oil, wheat, and fuel oil. Together, these five commodities accounted for 56% of all marine exports, most of which are natural resources (see Table B.1 in Appendix B).[15] By dollar value, the largest marine exports over the 2006–2015 period were oil and coal[16] with a value of $254 billion, or 29% of all marine exports (Statistics Canada, 2015). Iron ore, wheat, canola, and nickel are also important marine export commodities (see Table B.2). (The role of marine shipping in wheat exports from the Prairies is discussed in Section 3.2.)

By tonnes, the top marine imports are also bulk commodities: crude oil followed by coal, iron ore, and fuel oil (Table B.3). When measured by dollar value, however, marine shipping is also important for importing a diverse range of general cargo, including vehicles (e.g., cars, buses, motorcycles, auto parts, tractors, military vehicles), consumer goods (e.g., furniture, beverages, pharmaceutical products, clothing), machinery and equipment, and intermediate

13 The Statistics Canada (2015) data set does not include data on the value of domestic marine trade.

14 This depends on trade costs (including transportation costs) and destination market conditions. The statement is an inference based on trade theory like in Caliendo and Parro (2015) or Krugman *et al.* (2015).

15 Strictly speaking, volume is the amount of space that an object (a good) occupies. However, the trade and maritime economics literature refers to the weight (i.e., mass) of traded goods when it speaks of trade volume.

16 This is short for Harmonized System (HS) code 27, which includes all fossil fuels such as coal, coke, crude oil, refined petroleum products, and natural gas (i.e., mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes). This data set does not differentiate between oil, coal, and other fossil fuels.

imports (Table B.4).[17] Even though some cargos are heavy, their high market value[18] renders, in some cases, air transportation as an economically viable substitute for marine transportation (Hummels, 2007).

Canada differs from most other countries in that some of the same bulk commodities are among its top marine exports *and* imports (WTO, 2016, 2010). Crude oil, coal, and iron ore are the top three exports and imports when measured by volume.[19] This trade pattern can be partially explained by infrastructure, geographical location of resources, and transport costs. For example, the vast majority of marine trade in crude oil occurs in Atlantic Canada (Table B.5) despite the concentration of crude oil production in Alberta. This is because most crude oil exports are transported by pipeline from Alberta to the United States whereas most marine crude oil exports originate in and are almost exclusively (89%) shipped from Atlantic Canada (Statistics Canada, 2012). Similarly, the vast majority of crude oil imports (96%) also arrive in Atlantic Canada because transportation costs from Africa, the Middle East and/or Europe are lower than from Alberta (or Saskatchewan) (Table B.6; the role of marine shipping to global oil trade in Atlantic Canada is described in Section 3.4.) Similarly, coal and iron ore are both exported to Asia from Western Canada and imported to Eastern Canada from the United States. (The role of marine shipping in coal exports from British Columbia is discussed in Section 3.1.)

2.4.4 Canada imports a diverse range of general cargo including consumer goods, machinery and equipment, and intermediate imports. This is similar to other developed countries, reflecting integrated global supply chains.

Canada's pattern of trade in container cargo is similar to other developed countries (WTO, 2016). In general, this *intra-industry* trade — where countries export and import different varieties of the same goods (e.g., cars, clothing,

17 Vehicles and consumer goods are worth approximately 11% and 9% of total imports by value (Statistics Canada, 2015).

18 That is to say, they have a low weight relative to their monetary value (Hummels, 2007).

19 This is notably not the case for wheat, with Canada predominantly only exporting wheat by ship. The importance of marine shipping to wheat exports in the Prairies is described in Section 3.3.

electronics, furniture) is a common feature of global trade.[20] It enables firms to serve a larger market and offers consumers access to a wider range of products (Melitz & Trefler, 2012; Krugman *et al.*, 2015). Intra-industry trade has been a key factor in trade growth in recent decades (WTO, 2016). It has mostly been attributed to offshoring, which is enabled by free trade agreements, labour market conditions, production technologies, and, more generally, globalization (WTO, 2016).

As a result of these factors, marine shipping plays a key role in supporting Canadian retailers and other businesses that import consumer goods and/or rely on outsourcing their retail product lines through extensive, well-developed global supply chains. (Outsourcing is explored in Section 4.1.3 by illustrating the case of Canadian Tire.) Marine shipping is also important for the Canadian manufacturing sector because it supports *vertical specialization*, where many countries specialize in particular stages of the production of goods (Hummels *et al.*, 2001; Johnson & Noguera, 2012; Caliendo & Parro, 2015). Shipping is critical for importing intermediate goods, such as auto parts and electronic and communications equipment, which are later embedded in final products. (The importance of marine shipping to vertical specialization, and to machinery and equipment and intermediate imports, in Central Canada is discussed in Section 3.3.)

2.5 CONCLUDING REMARKS

By moving goods and people, marine shipping has played a formative role in Canada's history. For millennia, Indigenous peoples used canoes and other vessels to move a range of goods, including animal hides, fish, and shell ornaments throughout the continent. These trade routes and Indigenous communities formed the foundation for the explosion in transatlantic trade. Canadian staples such as fur, fish, and timber flowed to Europe and commodities such as cloth, guns, and tools flowed in return. Canada's economy grew, its population and cities expanded, and its environment deteriorated. By moving people, marine

20 Two features of the "new trade theory" drive intra-industry trade: economies of scale and love of variety (Krugman, 1981; Krugman *et al.*, 2015). The basic idea is that with economies of scale (increasing returns), firms that double their inputs more than double their output. Since goods can increasingly be produced more cheaply (i.e., more output for the same cost), producing at a larger scale becomes economically efficient. The reason that, at the extreme, economies do not rest on a single firm producing a single product is because different consumers prefer different varieties of a good (even though a given consumer may buy the same good every time). Under this approach, each firm produces a product variety that is differentiated from the varieties produced by other firms. However, while these varieties are not exactly the same, they are substitutes for one another; each firm continues to face competition from other producers in the industry.

ships contributed to the spread of European disease and conflict and facilitated colonization, both of which led to widespread depopulation of Indigenous peoples. Marine shipping is etched across the pages of Canadian history.

Today, despite other competing modes of commercial transportation, marine shipping remains an important part of Canada's economy. Canada continues to be heavily involved in the export of bulk natural resources, including oil, coal, and iron ore, and the import of specialized commodities from outside North America, including consumer goods, vehicles, and intermediate imports. This pattern of economic activity and integration in global value chains has profound impacts on Canadians, which are explored in the remainder of the report. Chapter 3 now illustrates the role of marine shipping in specific Canadian industries and regions.

3

Illustrations of the Role of Shipping in Canadian Industries and Regions

- The Coal Industry in Western Canada
- The Wheat and Canola Industry in the Prairies
- Intermediate Manufacturing Imports in Central Canada
- The Oil Industry in Atlantic Canada
- Annual Resupply in the Arctic
- Concluding Remarks

3 Illustrations of the Role of Shipping in Canadian Industries and Regions

Key Messages

- The economic impact of marine trade varies widely across Canada. The role of marine shipping depends on the goods being shipped, the locations of markets, and the structures of particular industries and regional economies.
- Inland natural resource industries, such as mining in Western Canada and commodity producers in the Prairies, derive significant benefits from marine shipping through Canadian ports. In the absence of access to Canadian ports, these industries would have to rely on access to U.S. ports, which would bring higher costs and a consequent loss of competitiveness.
- Manufacturing industries, such as those in Central Canada, also depend on marine shipping to access global supply chains. Intermediate imports are often carried by ship to Canadian firms, later to be re-exported as final goods, often to the United States.
- Atlantic Canada is dependent on marine shipping for exporting oil to the United States and importing it from Africa, the Middle East, and Europe. Marine ships also transport fuel oil, which serves the energy needs of local communities.
- Due to a lack of road or rail access, communities in the Canadian Arctic are highly dependent on marine shipping for the import of essential goods, such as food, fuel, and construction materials.

Shipping has an impact on all sectors of the economy and all regions of Canada, though the type and extent of impact vary due to differences in regional economies. Some industries are almost exclusively oriented towards global markets, selling most of their products outside Canada and transporting them by ship. Most metallurgical coal produced in Canada, for example, is exported and shipped overseas. Conversely, manufacturing firms often rely on shipping for the import of intermediate goods used as inputs in the production process. Both export- and import-dependent firms rely more on trade than domestically oriented counterparts, and more on shipping depending on the preferred mode of transportation and the locations of suppliers and customers. The structure and composition of the economy consequently lead to regional differences in reliance on shipping and trade. This chapter qualitatively explores these differences by illustrating the role that marine shipping plays in different regions through case studies on particular commodities and industries. The discussion is not intended

to provide a comprehensive account of the value of shipping to each region; rather, it aims to illustrate the various roles that shipping plays in Canadian industries and regions through selected data and examples.

3.1 THE COAL INDUSTRY IN WESTERN CANADA

Western Canada has long relied on marine shipping for exporting natural resources from coastal regions and the interior. Coal is a prime example. Along with oil and other fossil fuels, it constitutes the largest export from Western Canada by value. Coal and oil exports originating from British Columbia and Alberta accounted for $4.8 billion in 2015 (Statistics Canada, 2015). Given the nature of the commodity and its weight-to-value ratio, marine shipping is the only economically viable means of transporting coal to the overseas markets that constitute the primary destination for Canada's coal exports.

The large majority (over 90%) of coal produced in Canada originates from mines in British Columbia and Alberta (NRCan, 2012). Thermal coal is used in power plants for electricity generation, while metallurgical coal (also called coking coal) is used for making steel. Canada's coal output is divided almost equally between the two types, but their markets and destinations differ. Most of the thermal coal produced in Canada is used domestically for power generation, and only a relatively small amount is exported. In contrast, virtually all metallurgical coal produced in Canada is exported. In 2015, 92% of coal exported from Canada was metallurgical coal (NRCan, 2016). Canada is the world's third largest exporter of metallurgical coal after Australia and the United States (NRCan, 2016).

Canada's exports of metallurgical coal are primarily destined for overseas markets in Asia, specifically Japan, South Korea, and China (CPCS, 2015). Marine shipping is consequently critical in getting this coal to market. As of 2012, about 90% of Canada's coal exports were shipped by sea through two terminals at Vancouver (Westshore Terminals and Neptune Terminals) and the rest was shipped from Ridley Terminals in Prince Rupert (CPCS, 2015). Together these terminals handle roughly 30 million tonnes of coal a year. Coal exports originate predominately from mines in British Columbia though smaller amounts of thermal coal from mines in Alberta are exported by ship as well. Without access to shipping through Canadian ports, Canada's metallurgical coal producers would be forced to rely on U.S. ports farther from mines in northern British Columbia. This could be problematic given current congestion in U.S. ports, and would likely increase transportation costs (to global markets) or necessitate export sales only in the U.S. markets. In the latter case, Canadian producers would likely face steep decreases in the prices that they would be able to command given that the United States exports more metallurgical coal than Canada.

The economic consequences for the region of selling less coal would be considerable, especially where the coal industry plays a large role in the local economy. According to a PricewaterhouseCoopers study commissioned by the Coal Association of Canada, taking into account direct and indirect economic impacts, the coal industry contributed $5.2 billion in GDP in 2012, and accounted for 42,030 jobs (PwC, 2012). Wages and salaries from the industry were equal to $2.6 billion, with the industry reporting the average wage as twice that of the national average wage for employment (PwC, 2012). The jobs and wages are often concentrated in rural areas where other economic opportunities are limited.

A recent downturn in global market prices for metallurgical coal highlights this vulnerability. Demand for metallurgical coal is closely tied to global economic growth given steel's status as a key input for a diverse range of products from construction materials to vehicles and home appliances. Dampened global growth prospects and a weaker economy in China have reduced coal prices, and Canada's coal exports along with them. Five metallurgical coal mines were shut down in British Columbia in 2013 and 2014, resulting in the loss of 1,300 jobs (Cryderman & Jang, 2015). In the remote town of Tumbler Ridge in northeastern British Columbia, for example, this led to substantial outmigration with the mayor estimating that 40% of existing homes are now vacant. West Coast coal terminals are now operating below their full capacity (Cryderman & Jang, 2015). Without ready access to foreign markets through marine shipping, the Canadian coal industry and the economies of British Columbia's and Alberta's coal-producing regions would be put further at risk.

The medium- and long-term outlook for metallurgical coal, however, is positive. The OECD forecasts that global demand for steel will increase by 3.7% per year through 2025; recent projections suggest that Canada's coal exports could nearly double by 2045 (CPCS, 2015). Nearly all additional coal produced would be transported by rail from British Columbia's mines to its ports. Demand across most markets in Asia will remain steady and India, in particular, is expected to account for an increasingly large share of Canadian coal exports (CPCS, 2015). To handle this increase in export volumes, expansion may be required at Ridley Terminals in Prince Rupert and additional terminal capacity may eventually be needed (CPCS, 2015).

3.2 THE WHEAT AND CANOLA INDUSTRY IN THE PRAIRIES

Canada is a key participant in global agricultural markets, and agriculture remains critical to both the Prairies and to rural areas across the country. In 2013–2014, Canadian farmers produced approximately 31 Mt of wheat and 18 Mt of canola (CPCS, 2015). These crops currently contribute around $5.4 billion to Canadian GDP (Statistics Canada, 2016b). Wheat and canola production is

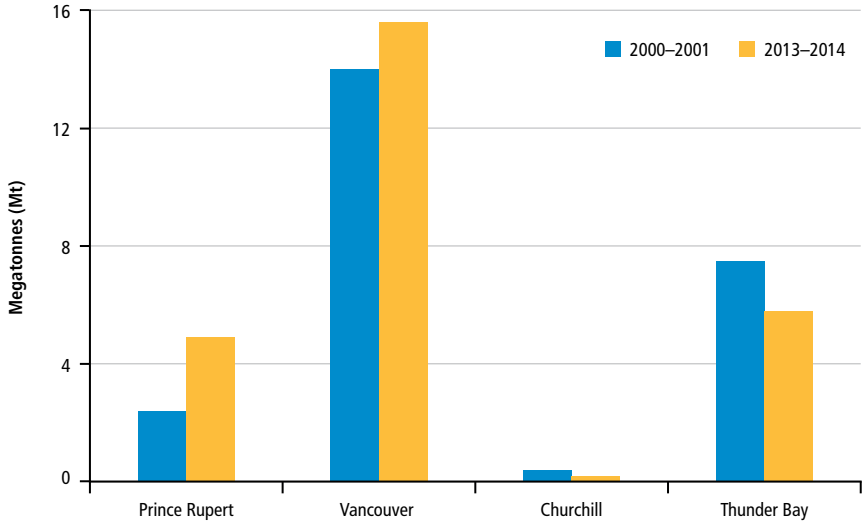
especially important to the economies of Saskatchewan and Manitoba, comprising approximately 5% and 2% of their respective GDPs (Statistics Canada, 2016a, 2016b). The vast majority of Canadian grains and oilseeds (roughly 90%) are produced in Manitoba, Saskatchewan, and Alberta (CPCS, 2015). Production capacity has grown to serve export markets; North American markets could not absorb the supply if export markets were lost. Access to these markets is critical to sustaining the industry.

In 2013–2014, Canada was the world's third largest exporter of wheat and fourth largest exporter of canola (Quorum Corporation, 2014; CPCS, 2015). Wheat and canola exports totalled 31 Mt in 2013, which is equal to approximately 60% of production (CPCS, 2015). Demand for Canadian wheat and canola is likely to increase with population and income growth in China and Mexico and as trade is further liberalized with the European Union, Asia, and others. According to CPCS (2015), wheat and canola exports are expected to increase by 244%, from 31 to 108 Mt, by 2045. These projections suggest that the United States will continue to be Canada's single largest export market, though its share will decrease from 19 to 10% of total exports (CPCS, 2015).

Wheat and canola are transported to markets using three major transport corridors: Pacific, Eastern, and United States–Mexico. The majority of wheat and canola production from the Prairies is moved by rail to the Pacific ports of Vancouver and Prince Rupert for export to Asia-Pacific markets (and, to a lesser extent, the Middle East and South America). As shown in Figure 3.1, in 2013–2014 approximately 16 and 5 Mt moved through the Vancouver and Prince Rupert ports, respectively (Quorum Corporation, 2014). Year-round operations and ready access to Asia-Pacific markets are the primary reasons that Pacific ports are the dominant wheat and canola export gateways. In 2013–2014, the Asia-Pacific market accounted for approximately 40% of total Canadian wheat and canola exports (Quorum Corporation, 2014; CPCS, 2015). The Eastern corridor includes wheat and canola deliveries by rail from the Prairies to Thunder Bay and from the Prairies, Ontario, and Quebec directly to ports and terminal elevators along the St. Lawrence (CPCS, 2015). Exports of Canadian wheat and canola to the United States and Mexico are also moved by rail and, to a lesser extent, truck, directly from the Prairies (Quorum Corporation, 2014; CPCS, 2015).

Marine shipping consequently plays a large role in Canada's exports of wheat and canola. While 26% of these exports (8 Mt) go to the United States, the remaining 74% (23 Mt) are exported to Asia-Pacific, Europe, and other regions from Canadian ports in the Pacific (Vancouver and Prince Rupert) and Eastern (Thunder Bay) regions. If normal shipping channels through Canadian ports were constrained or interrupted, Canadian exporters would be forced to route

shipments through the United States. This would partially erode the competitive advantage of Canadian exporters: they would need to transport wheat and canola over longer distances to reach Asia-Pacific and European markets and face port congestion in the United States. This would have no effect on the global price that they would receive (i.e., Free on Board price), but it would increase transportation costs. In the short run, Canadian exporters would likely see a decline in the profitability of wheat and canola exports. Over the long run, Canadian production of wheat and canola would likely decline, leading to negative economic and social impacts in regions where the crops are important to the local and regional economies.



Data Source: Quorum Corporation, 2014

Figure 3.1

Canadian Wheat and Canola Exports, by Port

The figure plots marine exports of wheat and canola by port (Mt) for the years 2000–2001 and 2013–2014.

3.3 INTERMEDIATE MANUFACTURING IMPORTS IN CENTRAL CANADA

This section provides an illustrative example of the value of marine shipping to Central Canada by examining its role in two dimensions of advanced manufacturing: vertical specialization and import of machinery and equipment (M&E). Marine shipping plays a role on two fronts. First, vertical specialization partially depends on it for the import of intermediary components or semi-finished materials

that are later embedded in advanced manufactured final products and often re-exported. Second, marine shipping is responsible for the import of M&E, which is used in advanced manufacturing.

Although the share of manufacturing in the Canadian economy has declined since the 1990s, the sector continues to be important to the economies of Ontario and Quebec. In 2015, manufacturing accounted for 12.8% ($81 billion) and 13.9% ($46 billion) of GDP and employed approximately 800,000 and 500,000 people in Ontario and Quebec, respectively (Statistics Canada, 2016a, 2016b). The nature of global trade has also changed dramatically due to free trade agreements, lower trade costs, and improved communication technology. Today, around one-half of world trade takes place in global supply chains in which different countries specialize in particular stages of a good's production (WTO, 2015). This vertical specialization is having profound impacts on advanced manufacturing in Central Canada because Canadian firms are highly integrated in these chains.

Vertical specialization is the use of imported goods as inputs to produce a country's export products (Hummels *et al.*, 2001). More specifically, it refers to the production of a good or a service that involves at least two countries and for which one country imports some of the inputs and will export at least some of the output (Conference Board of Canada, 2012). While measuring trade in intermediate goods is difficult (Johnson & Noguera, 2012), the data underpinning the quantitative trade model in Chapter 4 are nonetheless instructive. In 2015, electronic and communications equipment was among the top marine imports, ranking third in Ontario ($3.4 billion) and fourth in Quebec ($1.2 billion). This group of products has been identified as highly vertically specialized (Baldwin & Yan, 2014; Dion, 2000) and is a top export for both provinces (Statistics Canada, 2015).

However, marine shipping plays a much smaller role in the re-export of electronic and communications equipment than in their import as intermediate goods. It is responsible for approximately 10% and 20% of imports in Ontario and Quebec but only 4% and 5% of their exports, respectively. Overall, the vast majority of final products are re-exported to the United States by road and rail (Statistics Canada, 2015). This is in keeping with a Conference Board of Canada (2012) report that finds 85% of Canada's vertical specialization is with the United States. A similar story emerges for vertical specialization in the Ontario automotive industry. Vehicles/auto parts are the top marine import in Ontario ($5.9 billion) with marine shipping accounting for approximately 9% of them (Statistics Canada, 2015). However, marine shipping only accounts for 1.3% of exports as virtually all are transported to the United States (Statistics Canada, 2015).

Canadian firms are highly dependent on M&E imports because they need access to the technology that is embodied in the capital (CCA, 2009). M&E is the largest import sector overall, accounting for approximately 20% of total imports. Canada imports $40 billion more than it exports (Statistics Canada, 2015). Since the majority of M&E trade is with the United States, it is not surprising that only 13% of this trade is by ship. The macro picture, however, hides considerable diversity at the provincial level.

M&E is the second largest marine import sector in Ontario and Quebec, valued at $4.2 billion and $2.4 billion, respectively. However, approximately 25% of M&E is imported by ship in Quebec compared with only 8.6% in Ontario. This difference reflects the trading patterns of the two provinces: Quebec imports M&E from Germany, Italy, and other European countries while Ontario imports primarily from the United States. Quebec's reliance on marine shipping may increase in the future with the adoption of *Stratégie Maritime*, which aims to stimulate $9 billion in public and private investment in marine shipping infrastructure (Government of Quebec, 2015).

3.4 THE OIL INDUSTRY IN ATLANTIC CANADA

Beginning with the first North American commercial oil well in 1857 in Oil Springs, Ontario, the oil industry has played an important role in the economic and social fabric of Canada. Much of the controversy surrounding Canadian oil production — from the National Energy Program of the 1980s to current debates around pipeline construction, safety, and social license — has focused on the location of the economic and social benefits versus the location of the environmental and social costs. The majority (93%) of current Canadian crude oil production occurs in Saskatchewan and Alberta. Atlantic Canada produces the remaining 7% and refines oil produced elsewhere. Crude oil exports and imports are transported mostly from Atlantic Canadian ports (Table B.6).

Most, though not all, oil produced in Western Canada is transported by pipeline, rail, or truck to Gulf Coast refineries in the United States.[21] Nearly all oil produced in Atlantic Canada, however, is exported by ship, primarily to U.S. markets. Since more than 90% of Canadian oil exports (from all regions) are

21 Four major pipelines move Western Canadian crude oil across Canada and the United States (CAPP, 2014): the Enbridge Mainline and Kinder Morgan Trans Mountain pipelines, which originate in Edmonton, Alberta; and the Spectra Express and TransCanada Keystone pipelines, which originate in Hardisty, Alberta. Together, these pipelines provide about 3.7 million barrels per day (bpd) of capacity out of Western Canada (CPCS, 2015). A number of proposals for new and expanded pipelines that could deliver large volumes of crude oil to the East Coast, West Coast, U.S. Gulf Coast, and overseas are in various stages of regulatory approval or consideration (CAPP, 2014).

destined for the United States, pipelines or rail theoretically represent viable transportation alternatives for crude oil exports from Western Canada in the event of a shipping disruption. However, the impacts associated with a transition to these other modes make such modal substitution unlikely.

Although the cost of shipping oil by tanker is highly variable based on the average freight rate per barrel from West Africa to the United States[22] (Clarkson's Research, 2016; Poten & Partners, 2013), it is much lower than rail and broadly comparable to pipelines (Congressional Research Service, 2014; IHS, 2014). Marine shipping, however, is a more efficient mode of transportation in general. For example, it requires approximately 1.6 tankers per week (150,000 tonne capacity) to ship the approximately 12 Mt of oil crude per year currently exported from Saint John.[23] If this weekly volume were instead exported by rail or truck, it would take 2,600 railcars (carrying 90 tonnes each) or 4,700 truck trailers (carrying 50 tonnes each).

Marine shipping is also currently essential for the import of crude oil in Canada, which is refined into transportation fuels, furnace oil, and other products.[24] Over 99% of Canadian oil imports arrive by ship from Africa, the Middle East, and Europe (Statistics Canada, 2012), most of which are handled at ports in Atlantic and Central Canada. These imports serve Canadian refineries, which are often dependent on the supply of foreign crudes. For example, the oil refinery in Come By Chance, Newfoundland, sources only a small fraction of its crude oil from Atlantic offshore platforms. This is partly because the type of crude produced locally is ill suited to the refinery (which was built long before the discovery of oil offshore), but also because crude exports form part of the supply lines of major corporations that have little or no interest in the refinery. Except for a small proportion sold locally, refined product from Come By Chance is shipped to other parts of Canada and the world.[25]

22 For example, the average freight rate per barrel from West Africa to the United States between January 2013 and December 2014 was $2.87 with a standard deviation of 0.435 (i.e., a 68% chance that the freight rate is between $2.34 and $3.30).

23 Panel calculation based on crude oil imports to Saint John in 2011 (Statistics Canada, 2011).

24 Many Atlantic Canada communities lack access to natural gas for heating. Instead, they rely on oil furnaces or wood-burning stoves. Shipping therefore plays a role in ensuring many Atlantic Canadian households have a means of heating their homes.

25 Atlantic Canadian refineries have limited access to Western Canadian crude oil supplies in general (CPCS, 2015). At present, there is no transportation cost advantage in shipping crude oil from Western Canada to the refineries in Atlantic Canada rather than to the United States given the relatively easy access of Atlantic Canadian refiners to offshore and overseas crude. Eastern Canadian refineries received approximately one-third of their crude oil from Western Canada in 2013 (0.7 Mt), almost all of which went to Ontario refineries by rail (CPCS, 2015). The remainder was imported from Africa, the Middle East, and Europe (Statistics Canada, 2012). In fact, no refineries in Atlantic Canada or Quebec refined Western Canadian crude oil in 2015 (CPCS, 2015).

Unlike other provinces that produce and refine oil, Newfoundland and Labrador does not have the option of either importing or exporting its product by pipeline or rail. As demonstrated by the current low-energy price situation, a prolonged contraction would impose significant economic and social costs (e.g., unemployment) on Atlantic Canadian provinces. This is especially true for Newfoundland and Labrador, where the offshore oil and gas sector represents more than 25% of real GDP, and sometimes in excess of 50% of nominal GDP (Statistics Canada, 2016b). Any major, long-lasting disruption or moratorium on tanker shipping off Canada's East Coast would likely lead to a collapse of the Atlantic oil industry. This would have substantial economic, environmental, and cultural impacts on communities in Atlantic Canada.

3.5 ANNUAL RESUPPLY IN THE ARCTIC

Communities across the Canadian Arctic rely heavily on ships as a means of transporting goods to service the region. Given the lack of road and rail access or large runways, marine shipping is often the only viable mode of cargo transportation. The resulting dependence on shipping has pervasive implications for communities, affecting the availability and prices of food, construction materials, housing, and fuel for electricity, heating, and transportation. Shipping services are also hindered by the extreme arctic environment and lack of port infrastructure. Community resupply needs via ships are crucial, and may rise if the population grows or the needs of communities change (Prowse *et al.*, 2009; Hodgson *et al.*, 2013). Iqaluit, the largest community in Canada's eastern Arctic, illustrates the multifaceted social implications of dependence on shipping as a means of freight transportation (see Box 3.1).

Marine traffic in the Arctic is most heavily concentrated on the west sides of Baffin Bay and the Davis Strait, and in Hudson Strait and the west side of Hudson Bay. Many vessel types operate in the region, each with distinct operations and cargo. With some of the largest untapped oil and gas reserves in the world, the potential for increased marine activity due to oil and gas exploration and extraction is a possibility (Prowse *et al.*, 2009; Pizzolato *et al.*, 2014). The prospective increase in northern resource extraction projects (e.g., Baffinland's Mary River iron ore mine) and subsequent increases in exports of raw goods and materials from the North will not only increase regular bulk shipments, but also will likely require increased marine transportation during the construction phase of these projects (Hodgson *et al.* 2013). Small-scale commercial fishing operations in the Canadian Arctic are expanding further north as ice-free conditions persist for longer (Hodgson *et al.*, 2013).

Box 3.1
Marine Shipping and Iqaluit

Iqaluit is heavily dependent on marine shipping for the resupply of dry cargo and fuel during ice-free summer months. Each year some 1,400 tonnes of containerized cargo and 214,000 tonnes of non-containerized cargo are delivered to communities in the eastern Arctic by ship as part of the annual sealift (Brooks & Frost, 2012). Marine shipping is the only mode of transportation, other than aviation, linking the community to the rest of the Canadian and North American economy.

Iqaluit's energy system, for example, is entirely dependent on petroleum products imported by ship. Nunavut has no primary energy production and relies exclusively on imported fuels for all its energy needs, including electricity generation, heating, and transportation (Nunavut Energy Secretariat, 2014). These fuels are supplied by tankers during the seasonal resupply and stored in tanks on site in each community. Electricity in Iqaluit is provided by two diesel power plants, though the territory's energy provider has studied potential sites for hydroelectric facilities (Nunavut Energy Secretariat, 2014; CBC News, 2015a). These and other small-scale renewable power plants could eventually supply some of Iqaluit's energy needs but, given the lack of locally available energy resources, the community will remain dependent on imported fuels for the foreseeable future.

Similarly, Iqaluit is dependent on ships for the transportation of most general cargo including construction materials used in homes and other buildings. Local construction projects are dependent on shipping as a result and vulnerable to extended delays if cargo misses a sailing date. The limited availability of construction materials and their high transportation costs is one factor contributing to a housing shortage in Iqaluit — a condition shared across much of Canada's North (Nunavut Housing Corporation, 2012; Canadian Polar Commission, 2014). New port facilities planned for Iqaluit may ameliorate these conditions by expediting cargo offloading and reducing transport costs and the risks of delays; conversely, any further constraints on shipping would lead to increased costs and potentially exacerbate an already acute housing shortage.

The availability and affordability of food is also a challenge in Iqaluit and other Nunavut communities. Roughly 70% of Nunavut Inuit households are subject to either moderate or severe food insecurity (CCA, 2014). In Iqaluit, nearly one-third of households are food insecure, a rate three times the national average (Guo *et al.*, 2015). Food insecurity in the Arctic is multifaceted; one driver is the high price of store-bought food, reflecting high transportation costs and other logistical costs (e.g., inventory costs, shrinkage, labour, energy costs) (CCA, 2014). In Iqaluit, perishable food items are imported by air, but bulk, non-perishable items are often delivered by ship. Without the option of marine transport, prices for such foods would increase further.

3.6 CONCLUDING REMARKS

Some of the ways in which Canada's regions are dependent on shipping are readily apparent and widely acknowledged. For Arctic communities, shipping is often the only economical means of accessing essential goods, such as food, fuel, and construction materials. Similarly, it is often the only way to transport Canada's abundant natural resources to overseas markets. Any restriction in access to shipping would consequently increase transportation costs and erode the competiveness of these industries. Other ways in which Canada's regions and industries are dependent are less obvious, but no less important. This is particularly the case with imports. Manufacturing industries across the country depend on marine trade for intermediate inputs and M&E, both of which are essential for production. Disruptions in marine shipping would have sizable impacts on the regional economies in which these industries are embedded.

The case studies have highlighted the different roles that shipping plays in supporting economic activity across particular industries and regions. Chapter 4 now considers the value of marine shipping at the national level, taking into account economic, cultural, environmental, and security dimensions of value.

4

National Perspectives

- Economic Impacts
- Cultural Impacts
- Environmental Impacts
- Security Impacts
- Concluding Remarks

4 National Perspectives

Key Messages

- The primary contribution of marine shipping to Canadian GDP is derived from its role in facilitating international marine trade. Estimates suggest that this economic impact is equal to about 1.8% of Canadian GDP (about $30 billion in 2016).
- The Canadian commercial marine shipping industry directly contributes about $3 billion to Canada's GDP through employment and other direct impacts.
- Many Canadians see themselves as citizens of a maritime or seafaring nation, define aspects of their identity from marine employment, and improve their well-being by consuming a wide variety of marine-imported products.
- Overall, marine shipping is responsible for about 1% of total Canadian GHG emissions, and is the least GHG emission-intensive (per tonne-km) mode of transportation.
- Illegal drugs and counterfeit goods enter Canada by all modes of transportation including by ship.
- Increased foreign shipping activity in the Arctic may have implications for Canadian sovereignty.

The multidimensional nature of the social value of commercial marine shipping is apparent at the national level. This chapter assesses the four dimensions of social value defined in Chapter 1. It examines the extent to which the marine shipping industry and marine shipping services contribute to Canadian GDP, using a novel quantitative trade model commissioned by the Panel. It also reviews positive and negative impacts on culture, environment, and security.

4.1 ECONOMIC IMPACTS

The national economic impact of marine shipping is reflected in (i) the GDP of the Canadian marine shipping industry; and (ii) the GDP associated with the role of marine shipping in facilitating international trade, which is estimated using the trade model commissioned by the Panel.

4.1.1 The Canadian marine shipping industry directly contributes around $3 billion to Canada's GDP.

Economic impact studies of particular industries are increasingly common, with recent examples from Canadian industries as diverse as forestry, canola, mining, automotive, air transportation, defence, wine, and the arts. These studies estimate a narrow definition of economic impact by using common indicators of economic

activity like GDP, sales, employment, tax revenue, and others. Most employ a common methodology, although the application of modelling assumptions varies significantly (Dooms *et al.*, 2015).

The Panel is aware of three studies that have quantified the economic impact of marine shipping in Canada in the past two decades (LECG Corporation, 2004; DFO, 2009; Martin Associates, 2011). They are summarized in Table 4.1. Collectively, they decompose economic impact into three channels. First, *direct impact* consists of the economic activity and employment in the Canadian commercial marine shipping industry, including shipping services (e.g., transportation of goods, insurance, bunkering, ice breaking); port services (e.g., tug, pilotage, inspection, loading/unloading); infrastructure; and shipbuilding. Second, *indirect impact* includes the economic activity and employment supported down the supply chain as a result of the purchase by shipping companies of goods and services from Canadian industries such as fuel, iron/steel, communications, and business services. Third, wages spent in the Canadian economy by individuals directly and indirectly employed in the marine shipping industry are often classified as *induced impact*.

Economic impact analysis uses a combination of methodologies (Dooms *et al.*, 2015) to measure these three channels. The three studies summarized in Table 4.1 are a good example of this. Direct economic impact is often *measured* with national statistics like GDP share, total employment, labour income, net exports, firm revenue, and tax revenue (LECG Corporation, 2004; DFO, 2009; Martin Associates, 2011; Transportation Research Board, 2012). Indirect and induced impacts, by contrast, are *estimated* from national statistics using input-output (I-O) and macroeconometric models (LECG Corporation, 2004; DFO, 2009). Martin Associates (2011), however, estimates the wages spent in the Canadian economy using a survey of 900 firms that provide port services in the Great Lakes-St. Lawrence Seaway.

Table 4.1

Summary of Selected Economic Impact Studies

	LECG Corporation (2004)	DFO (2009)	Martin Associates (2011)
Direct Impact	$3 billion GDP	$3 billion GDP	–
	36,000 employees	41,592 employees	48,288 employees
	$1.7 billion net exports	$2.1 billion labour income	$2.4 billion labour income
	–	–	$15.8 billion business revenue
Indirect Impact	$1.1 billion GDP	$1.1 billion GDP	–
	24,000 employees	18,351 employees	21,947 employees
	–	$688 million labour income	$1.3 billion labour income
Induced Impact	$5.1 billion GDP	$1.3 billion GDP	–
	33,000 employees	18,093 employees	28,320 employees
	–	$923 million labour income	$905 million labour income
	$1.7–2.4 billion Fed tax revenue	–	$1.4 billion Fed tax revenue
	$1.7–2.6 billion Prov tax revenue	–	$559 million Prov tax revenue
Total	$9.1 billion GDP	$5.5 billion GDP	–
	93,000 employees	78, 035 employees	98,556 employees
	–	$3.7 billion labour income	$4.5 billion labour income
Data Year	2000	2006	2010
Data Source	National statistics	National statistics	Survey
Methods	I-O & macroeconometric models	I-O model	I-O model

The table presents a summary of selected economic impacts studies. Figures in columns two and three are in Canadian dollars and those in column four are in U.S. dollars.

Two of the economic impact studies in Table 4.1 show that the Canadian marine shipping industry *directly* contributes $3 billion to Canadian GDP. When accounting for *indirect* and *induced* impacts, there are wide ranges of estimates, both across and within the studies. For instance, the Canadian marine shipping industry is estimated to contribute between $5.5 and $9.1 billion to Canadian GDP and between $1.4 and $2.4 billion in federal tax revenue.

GDP is only an approximate measure of national economic impact for three reasons. First, GDP is based only on value added. It does not account for the value provided to other industries that purchase shipping services. Total industry sales would be a better measure of value to these industries. Second, the GDP of the shipping industry is a measure of its costs, rather than its benefits. Like with other trade costs, such as tariffs, currency fluctuations, and information asymmetries (Hummels, 2001; Anderson & van Wincoop, 2004), there is value when they fall. If, for example, shipping productivity improved, shipping costs would fall. If the amount of shipping services remained constant, the GDP of marine shipping would also fall.[26]

Third, and most fundamentally, GDP does not capture the role that shipping services play in specialized regional production and trade patterns. Because those patterns likely reflect the optimal choices of producers and consumers, the observed patterns in the absence of marine shipping would either not exist or be less efficient. Hence, marine shipping creates economic value by making possible certain production and trade patterns. This value is not captured by the market; as a result, it is not captured by conventional economic measurements like GDP. Assessing the impact of these patterns is difficult. It requires measuring the gap between the *observed* patterns and the *hypothetical* patterns that would prevail in a world without marine shipping. The trade model in the next section is a quantitative attempt to do so.

To understand how the national economic impact of marine shipping arises, consider the following two questions. What would the economic structure of agriculture in the Prairies look like if marine shipping were not available to bring produce to markets? What would Canada's coal imports look like if sourcing internationally by marine mode were not available? In the first case, the economic impact of marine shipping is the gap between the GDP generated by the observed agricultural specialization and the one observed in the hypothetical absence of marine shipping. In the second case, the economic impact is the difference between the resources devoted to transporting coal by ship and the resources that would need to be used (cost incurred) to satisfy demand using the next-best alternative mode of transportation and trading partner. Both of these economic impacts are not reflected in GDP. The economic impact of shipping on Canadian

26 Observe that lower total spending on shipping would be preferable from a national economic perspective. The economic value of shipping reflects the fact that scarce resources have to be devoted to shipping so that they cannot be employed in alternative uses. If shipping became even more efficient, so that its unit costs fell, fewer resources would be required for shipping and could be employed in alternative uses. Since shipping does not directly contribute to consumption but only facilitates it, if the resources devoted to shipping could be used directly in consumption, the economic value to society would increase.

producers and consumers is embedded in all the production and consumption that shipping facilitates. That impact is not readily apparent. Measuring it requires a different approach, as described in the next section.

4.1.2 Estimates from the Panel's quantitative trade model suggest that the economic impact of commercial marine shipping in Canada is about $30 billion (1.8% of real GDP).

The primary contribution of marine shipping to Canadian GDP is derived from its role in facilitating international marine trade, thereby shaping production and trade patterns. As argued above, data on this contribution are not available from national statistics and cannot be estimated using economic impact methods. To more deeply understand the economic impact of marine shipping on national income and welfare, the Panel commissioned the development of a quantitative trade model to measure the effects of international marine trade on the Canadian economy (see Box 4.1). Estimates from this model, which are based on hypothetically eliminating Canadian marine trade, reflect the broader economic impact of marine shipping associated with its role in transporting goods to and from Canadian shores.

As highlighted in Box 4.1 and Appendix A, the Panel's quantitative trade model is just that, a model. It is intended to be a helpful simplification of the complex relationship between marine shipping and international trade. Like all analytical models, it relies on a set of assumptions, modelling choices, and uncertainties, which are outlined below and described in detail by Caliendo and Parro (2015). The Panel recommends exercising caution in (over-) interpreting the findings of such an exercise. In bringing together the macroeconomic aspects of leading empirical modelling approaches from international economics and the more microeconomic aspects of transportation economics, however, it is certainly an improvement in measurement. The Panel considers the model estimates to be accurate at least in their general magnitude, as they take into account potential changes in production and trade patterns. In this sense, it is a reasonable approximation of the trade-related economic impact of marine shipping.

Box 4.1
Using a Trade-Based Model to Estimate the Economic Impact of Marine Shipping

Based on Caliendo and Parro (2015), the quantitative general equilibrium trade model commissioned by the Panel accounts for 41 countries and 34 industries, with I-O linkages and 5 modes of transportation. The model is estimated using Statistics Canada (2015) data on trade, location, and transportation. Production and additional trade data for Canada and other countries are from the World Input-Output Database (Timmer *et al.*, 2015). Additional information on data sources can be found in Appendix A.

The model assumes that in each industry, heterogeneous firms that produce final goods search for the lowest-cost supplier of intermediate goods across countries and transportation modes (i.e., marine, road, rail, air, other (pipeline)). Transportation modes are not modelled explicitly as separate industries, but as a use of scarce resources required to ship goods.

While explicitly modelling the industries would be worthwhile, to the best of the Panel's knowledge it is not currently possible to model several separate transport industries in a full general equilibrium model, when some of those industries (especially marine and air) cannot be approximated by a perfectly competitive market structure. The upside of this approach is that it captures substitution between transportation modes and trading partners in a flexible manner. In other words, in the model, changes in the cost of one mode of transportation encourage producers to substitute to another mode of transportation and facilitate access to cheaper intermediate goods from other possible locations. Potentially, these effects could vary by country and industry due to specialization in different industries that use marine shipping with different intensities.

Incorporating different modes of transportation in an economically meaningful and analytically tractable way represents a novel contribution to the international trade literature, which completely abstracts away from modelling transportation modes. Changes in transportation costs lead to changes in production, trade, wages, and prices. They also affect production and trade patterns, thus providing a useful lens for looking at the full economic impact of marine transportation. Ultimately, this model enables quantification of the relationship between marine transportation and Canadian GDP over the long run when firms can adjust to changes in trade costs.

Table 4.2 summarizes the effects of hypothetically shutting down the different transportation modes, expressed in percentage changes in real GDP. It highlights that shutting down marine transportation for Canada — while keeping both the costs of marine trade for all other countries and the costs of alternative transportation modes for Canada constant — would result in an estimated long-run permanent reduction[27] of roughly 1.8% in Canada's real GDP or around $30 billion in 2016. The model is based on 2011 data, so $30 billion is an extrapolation from the model estimate.[28] This represents a substantial welfare loss for Canada. The loss is roughly the same size as the economy of New Brunswick or Winnipeg, or the Canadian agriculture, forestry, fishing, and hunting sector. The estimated effect of shutting down trade by road (i.e., a long-run permanent reduction of 4.4%) is much larger since it is the dominant mode of transportation for Canadian trade (recall Figures 2.3 and 2.4).

Table 4.2

Estimated Effects of Shutting Down Transportation Modes in Canada

Transportation Mode	Effects on Real GDP (%)
Marine	-1.77
Road	-4.44
Rail	-1.49
Air	-0.43
Other (Pipeline)	-0.94

The total effect of hypothetically shutting down marine transportation on Canadian GDP (1.77% reduction) is approximately nine times larger than the direct contribution of the marine shipping industry to Canadian GDP ($3 billion or 0.19%). The reason is that, as explained above, marine transportation enables production and trade patterns and allows Canadians to access international markets. By enabling trade, marine transportation allows for more efficient specialization and cheaper access to intermediate goods and final consumers, all of which increase productivity in many Canadian industries. This impact

27 In what follows, *reduction* will always refer to a long-run permanent reduction.

28 Canadian GDP in November 2016 is estimated at $1.69 trillion (Statistics Canada, 2017). In 2011, 1.8% of Canadian GDP was $28 billion.

is not captured by conventional measures such as GDP or industry sales.[29] Consequently, the total effect of maritime trade on the economy is much larger. It takes a different and more complex modelling approach than is used in economic impact studies to measure this effect.

The rounded figure of 1.8%, though large compared with the marine industry's direct share of GDP, may seem relatively small. However, consider the following two points. First, marine shipping transports 21% of Canadian exports and imports (trade) by value. For Canada, the trade-to-GDP ratio was 65% in 2015 (World Bank, 2015).[30] It follows that marine ships are only carrying 13.7% of GDP. By comparison, and noting that road, rail, air, and pipeline transportation options still exist, 1.8% represents a sizable reduction in GDP. Second, the model is a long-run model in which all resources are fully employed and can be reallocated across industries in response to changes in the marine trading environment. This implies that the model already takes into account the long-term adjustment of the Canadian economy to shutting down marine transportation. Some industries would shrink and, theoretically, their resources (labour and capital) would move to alternative uses.[31] Furthermore, a part of shutting down marine transportation could be absorbed by the economy as producers and consumers switch to alternative modes of transportation (see Table 4.3). This would benefit other transportation modes as increased maritime trade costs incentivize producers to search for an alternative cheaper mode. The model estimates that there would be a greater proportional increase in air (6.88% change) than in road (6.06%) or rail (3.99%). The short-run impacts of shutting down marine transportation would likely be many times larger if resource reallocation were sluggish (short-run) or could not occur at all between some industries (structural).

29 For example, the Prairies produce a lot of agricultural products such as wheat and canola that heavily rely on marine transportation to be brought to markets. It is unlikely that this specialization pattern could persist in the absence of marine transportation (see Section 2.2). Hence, the economic impact of marine transportation not only includes the GDP or sales of the shipping industry, but also the difference between the GDP of the Prairies with and without the marine mode. This impact is not captured by any conventional measure of economic activity. It could be captured by a marine shipping monopoly that explicitly prices to extract the rent of the second-best alternative, like in an auction, but this is clearly not what is observed in reality. Hence, conventional GDP measures do not capture this type of economic impact at all.

30 The ratio of trade to GDP requires interpretation. Trade is not 65% of GDP. Specifically, the total value of trade is measured as the *final market value* of exports and imports, and GDP is measured as *value added* only. The measures are not compatible or comparable. However, this does allow one to convert the value of trade into (percentage) units of GDP.

31 This is a standard assumption in most international trade models and in all long-run general equilibrium models in economics.

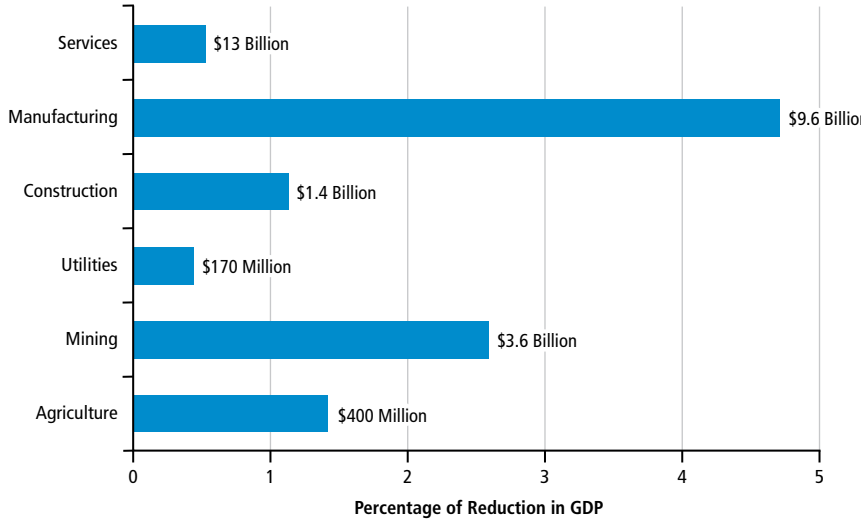
Table 4.3

Trade Substitution Effects of Eliminating Marine Shipping in Canada

Transportation Mode	Trade Change (%)
Air	6.88
Road	6.06
Rail	3.99

The Panel's model can also provide estimates of the change in Canadian GDP from a reduction in shipping costs. The model finds that a 10% reduction in the cost of marine trade would increase real Canadian GDP by 1.5%. This effect is larger for marine than other modes of transportation.

The impact of eliminating international marine shipping in Canada varies by sector. As shown in Figure 4.1, the largest predicted long-run permanent reductions in real GDP would occur in manufacturing and mining[32] (4.7% and 2.6%, respectively), with the smallest in utilities and services (0.4% and 0.5%, respectively). However, given that the services sector accounts for 78% of Canadian GDP, the absolute reduction would be the largest, at approximately $13 billion.



Data Source: Panel Calculations and Statistics Canada, 2016a

Figure 4.1

Reduction in Canadian GDP from Eliminating Marine Shipping, by Sector

The figure presents the percentage reduction in the GDP of each Canadian sector that would result from hypothetically shutting down commercial marine shipping. The dollar value of these reductions is also included. Even though the services sector only declines by about 0.5%, the dollar value of this decline is the largest because it is the largest sector of the Canadian economy.

32 This includes mining, quarrying, and oil and gas extraction.

The impact of eliminating marine shipping in Canada varies by industry. It depends on both an industry's degree of exposure to marine trade and on the importance of certain industries as suppliers of intermediate goods to other industries. The model estimates larger reductions in real GDP for *tradable industries*[33] because they are more directly exposed to marine trade. These 16 industries are plotted in Figure A.1 and described in Appendix A. They include mining; transport equipment; and food, beverages, and tobacco. The model estimates smaller, but still considerable, reductions in real GDP for *non-tradable industries*. These 18 industries are plotted in Figure A.2 and described in Appendix A. The largest reductions are found in those non-tradable industries that use marine-imported intermediate goods as material inputs in production. This includes construction, wholesale trade, and advanced manufacturing, for example.

Figures A.1 and A.2 present the contribution of each industry to the estimated reduction of 1.8% in real GDP as a consequence of shutting down maritime trade. Specifically, each bar in the figures represents the percentage contribution of that industry to the overall estimated reduction in real GDP, so that all industries sum to 100%. Among tradable industries, mining (10.5%), transportation equipment (9.6%), and food, beverages, and tobacco (7.4%) contribute the most to this overall estimated reduction. By comparison, while the leather industry experiences the largest reduction in real GDP (12.6%), it only explains a small portion of the overall estimated reduction because it represents a small share of Canadian real GDP. Among non-tradable industries, construction (5.1%) contributes the fifth largest amount to the overall estimated reduction. The model's I-O linkages explain this result. Marine trade affects production and prices in construction because the industry uses intermediate goods from tradable industries that are directly exposed to marine trade. Moreover, this I-O effect in construction has a large aggregate effect in the Canadian economy as it accounts for more than 6% of Canadian GDP. This finding reinforces the importance of accounting for I-O linkages in measuring the impact of marine shipping.

33 The output produced in tradable industries is or could be traded internationally (e.g., bulk commodities, consumer goods) whereas the output produced in non-tradable industries cannot be traded internationally (e.g., construction, healthcare). This is a standard distinction used in the international trade literature.

To reiterate, the model is based on the hypothetical situation of shutting down international maritime transportation *to and from Canada only*, while keeping the costs of marine trade within Canada and between the other countries unchanged. The Panel does not believe that this exercise is realistic because marine shipping will not be shut down. Rather, it is a useful exercise to quantify the economic impact of marine trade on Canada since it captures the effects of marine trade that do not show up in more conventional measures such as GDP. As such, the model estimates depend on the realism of its assumptions. That domestic marine trade in Canada remains unchanged calls for two comments. First, since Canada is a "small open economy,"[34] this implies that shutting down its marine trade (but not its road, rail, air, and pipeline trade) would only have a small effect on global international trade. Second, since domestic marine trade is only 15.6% of total marine trade,[35] 1.8% is a relatively precise estimate of the long-run permanent reduction in Canadian GDP.[36] Although domestic marine trade is virtually indispensable for some regions, the overall effect on the Canadian economy would be quite small.

Overall, the Panel believes that this approach provides a general order of magnitude estimate of the full national economic impact of marine shipping on Canada. The key message is that this impact is sizable at about nine times larger than the GDP of the marine shipping industry.

4.1.3 Marine shipping facilitates production outsourcing, lowering costs and prices for Canadian industry and consumers.

Marine shipping enables firms to buy their supply of goods from other countries. *Outsourcing* (the import of more advanced and lower-cost goods for use as production inputs or for domestic resale) has been a common practice for centuries. It takes advantage of the efficiency of specialization to lower both costs (for importers) and prices (for consumers) while increasing the variety of products available. Box 4.2 provides an illustrative example of the role of marine shipping in Canadian Tire's global sourcing model.

34 This description means that a country engages in international trade (and has relatively free trade), but does so without significantly altering global commodity prices and other factors (e.g., exchange rates, interest rates, incomes). It is a good description of Canada which accounts for 2.3% of global trade (WTO, 2016).

35 By volume. Recall Section 2.4.

36 Unfortunately, the existing data on domestic marine trade did not allow the Panel to refine these estimates.

Offshoring is related to outsourcing, but different. It takes advantage of low-cost, high-capacity manufacturing, enabling firms to produce their own supply of goods. These goods are then imported and used as production inputs or for domestic resale. It is not without controversy. The net effect on domestic employment is generally positive (Liu & Trefler, 2008); however, it has created some unemployment among lower-skilled groups of workers and its impacts are localized in certain regions (e.g., industrial cities, rural areas). While much of this economic dislocation appears more likely attributable to education gaps and information technology (Moretti, 2012; Harari, 2016), the financial, psychological, and social toll is significant. Valid concerns have also been raised about environmental impacts and labour standards in countries where production physically occurs. There is no single correct belief about the value of offshoring as a mode of production. It depends on how one weighs different dimensions of value — and ultimately upon personal values.

Box 4.2
Role of Marine Shipping in Canadian Tire's Global Sourcing Model

Today, more than 80% of Canadians shop at a Canadian Tire store at least once per year (Canadian Tire, 2016). Founded in 1922, Canadian Tire was the fifth largest Canadian-owned retailer and the seventh largest retailer overall in Canada in 2011, with $8.4 billion in sales (Industry Canada, 2013). It employs some 58,000 people across its retail, automotive, and finance business lines (Canadian Tire, 2010).

Like retail giants Wal-Mart and Costco, Canadian Tire relies heavily on outsourcing its product lines through extensive, well-developed global supply chains. In 2014, it sourced 41% of its products (by cubic volume) offshore, of which 90% came from Asia (McKenna, 2016).* Canadian Tire is the 22nd largest importer in the North American market, broadly comparable in volume to Costco, Nike, and Gap. In 2015, Canadian Tire imported more than 29,000 cargo containers, which included a diverse range of goods such as sporting goods, hardware, electronics, housewares, tires, and auto accessories. Around 90% of them were shipped through the Port of Vancouver, making Canadian Tire the port's largest importer (by number of containers) (McKenna, 2016).

The reliability and low transportation costs of marine shipping are the lynchpin of Canadian Tire's global sourcing model. In general, global sourcing allows a firm to achieve competitive price points and produce a variety of products. More specifically, by accessing the lower-cost and greater-capacity manufacturing in Asia, Canadian Tire can offer strong private label programs and design, bring to market innovative products, and provide a buying cost advantage (McKenna, 2016).

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Without marine shipping, Canadian Tire's global sourcing model would likely collapse, leading to discontinued product lines and price increases (McKenna, 2016). Although, in principle, product lines could be shipped via air, this transportation alternative is neither cost-effective nor feasible from an operations perspective. Alternatively, a more likely scenario would be for Canadian Tire to ship via U.S. ports. However, the lack of Canadian Tire retail stores in the United States makes its ports less competitive options for a purely Canadian retailer (McKenna, 2016).

Overall, Canadian Tire's global sourcing model has led to unit cost reductions and increased profitability for the retailer and lower prices and greater product variety for Canadian consumers.

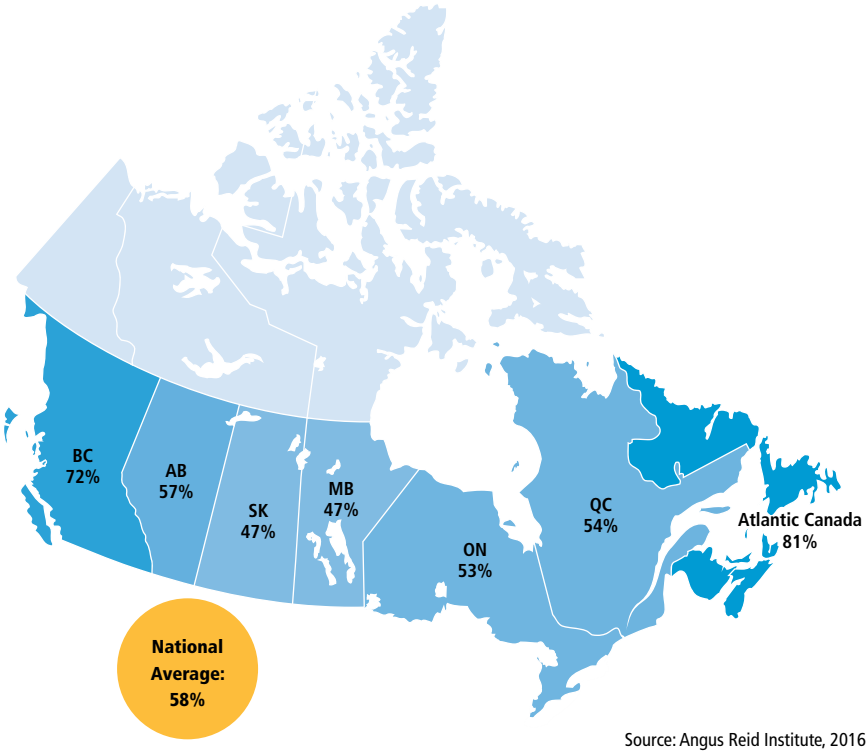
* Approximately 70% of products by cubic volume come from the Chinese cities of Shanghai, Shenzhen, and Ningbo (McKenna, 2016).

4.2 CULTURAL IMPACTS

4.2.1 According to a recent poll, many Canadians see themselves as citizens of a maritime or seafaring nation.

Canadians are broadly cognizant of the importance of shipping to the country and as an element in their national identity. According to a recent survey, 58% of Canadians identify either "strongly" or "a fair amount" as citizens of a maritime or seafaring nation (Angus Reid Institute, 2016).[37] Only 14% of Canadians report that they do not at all see Canada as a maritime or seafaring nation. While these perceptions vary by region and are predictably strongest on the coasts (Figure 4.2), nearly half of respondents in Central Canada see Canada as a maritime or seafaring nation. Most Canadians believe that shipping is important to Canada's economy, to coastal communities, and to Canada's ability to export and import goods. Such sentiments, however, may be changing. Maritime cultural identification is strongest among older Canadians, especially among older men; younger generations are less likely to recognize the central role of shipping in Canada's development and identity (Angus Reid Institute, 2016).

37 A definition of "maritime or seafaring" nation was not provided to respondents.



Source: Angus Reid Institute, 2016

Figure 4.2

Percentage who Identify as Citizens of a Maritime or Seafaring Nation

The map shows the percentage of respondents who either identify "strongly" or "a fair amount" as citizens of a maritime or seafaring nation, based on a sample of 2,290 Canadians.

4.2.2 Employment in the marine shipping industry plays a role in individual identity of Canadians.

The economic impact studies in Table 4.1 highlight a wide range of employment and labour income estimates. When accounting for indirect and induced impacts, the Canadian marine shipping industry employs between 78,000 and 99,000 individuals and generates between $3.7 and $4.6 billion in labour income. The significance of marine-related employment, however, is not fully reflected in these metrics. Employment is a critical component of individual identity (Akerlof & Kranton, 2010) and in the organization of social life (Edgell *et al.*, 2015). Indeed, it influences identity, health, family relationships, social relationships, and well-being (Akerlof & Kranton, 2010). Employment also has numerous social and cultural dimensions and traditions (Rothman, 1998; Hodson & Sullivan, 2002; Albert & Weeden, 2011; Vallas, 2011). The Panel is not aware of a literature that explores these impacts for marine shipping employment specifically.

4.2.3 Marine shipping facilitates consumption of a wide variety of products, improving the well-being of Canadians.

Individual well-being is determined, in part, by the consumption of goods and services (Offer, 2012). Marine shipping plays a key role in importing consumer goods across Canada. Over the 2006–2015 period, marine shipping transported more than $85 billion of imported consumer goods (Statistics Canada, 2015). This includes furniture, beverages, clothing, and other commodities found in retail stores across Canada. Relative to their weight, some of these goods have high margins (e.g., luxury furniture, speciality designer clothes, and speciality wines). They are relatively specialized and of high quality, produced according to comparative advantage. In principle, these could be shipped by air to Canada from non-U.S. countries, which would likely increase costs for importers and prices for consumers.[38] Other goods, by contrast, have relatively low margins (e.g., mass-produced furniture and clothing, beer, household products). These low price goods are less specialized and of lower quality, produced according to economies of scale. It would be too costly to import them by air to Canada from non-U.S. countries.

Marine shipping thus supports the import of a variety of consumer goods that range in price and are either specialized or differentiated in quality. It is sometimes argued that goods at the low end of the quality spectrum have short life spans and adverse environmental consequences (Franklin, 2002). However, a greater variety of products is generally assumed to improve consumer well-being. The most reliable estimate suggests that the four-fold increase in consumer product variety between 1972 and 2001 improved consumer welfare in the United States by an amount equal to 3% of GDP (Broda & Weinstein, 2004). Overall, marine shipping facilitates consumption of a wide variety of products, which improves the well-being of Canadians.

4.3 ENVIRONMENTAL IMPACTS

4.3.1 Marine shipping produced 6.7 Mt of GHG emissions in 2013. This is about 1% of Canada's GHG emissions in 2013.

Emissions from fossil-fuel combustion in marine shipping, like any other mode of transportation, contribute to rising GHG concentrations in the atmosphere, resulting in changes in the earth's climate and associated environmental and social impacts. According to the International Maritime Organization (IMO), marine shipping accounted for 2.1% of global GHG emissions in 2012 (IMO, 2015). In Canada marine shipping produced 6.7 Mt of GHG emissions

38 This implicitly assumes that if air transportation were a lower-cost mode of transportation, these firms would have already switched to it.

in 2013 (NRCan, 2013). This is 7.9% of Canada's freight transportation emissions (85.2 Mt) and roughly 1% of its GHG emissions. Road transportation produced the majority (83%) of Canada's freight transportation emissions (NRCan, 2013).

4.3.2 Marine shipping is the least GHG emission-intensive mode of transportation.

GHG emissions from marine shipping should be considered in the context of the emissions profiles of alternative modes of transportation.[39] Marine shipping is the least GHG emission-intensive mode of transportation (IMO, 2015). Based on emission intensities, a 2013 study estimated that switching from marine shipping to rail or road transportation could increase Great Lakes-St. Lawrence Seaway GHG emissions by between 19% and 533%, if all marine transportation were substituted for rail and road, respectively (Research and Traffic Group, 2013).

While GHG emissions are regarded primarily as a national environmental challenge, many of the abatement strategies pertain to ships and ports. Ship designers are pursuing gains in energy and fuel efficiency; companies are exploring natural gas and biofuels as alternative fuels; and, in some cases, ships are supplementing power generation with renewable energy sources such as wind and solar power. Ports have a number of avenues for pursuing GHG reductions. For example, the Port of Montréal's replacement of its diesel locomotives with multiple generator locomotives has reduced GHG emissions by 90% (Montreal Port Authority, 2014a). All the port's initiatives to reduce emissions have resulted in a 17.3% decrease in GHG emissions per tonne of cargo handled since 2007 (Montreal Port Authority, 2014b). However, absolute levels of GHG emissions at many Canadian ports continue to increase given growing volumes of trade. A transition to alternative technologies could help reduce, and eventually eliminate, these GHG emissions.

4.4 SECURITY IMPACTS

4.4.1 Illegal drugs and counterfeit goods enter Canada by all modes of transportation including by ship.

The presence of organized crime has been documented at Canada's three largest commercial marine ports in Vancouver, Montréal, and Halifax (Public Safety Canada, 2015). Organized criminal groups have engaged in activities aimed at infiltrating, corrupting, and (to a lesser degree) intimidating industry

39 Although it is difficult to generalize the overall change in GHG emissions from substituting between modes of transportation, it can be instructive. For instance, McIntosh (2013) finds that switching coal shipments from ships to rail would result in lower emissions (though higher costs), given the shorter travel distance when transported by rail.

insiders and security and law enforcement personnel in support of criminal activities. These include the import of illegal drugs and counterfeit goods, and cargo theft. Since 2005, Canadian ports have become more involved in both the export of domestically manufactured synthetic drugs to markets abroad and the import of high-potency synthetic drugs and precursor chemical shipments for domestic production. For example, evidence suggests that some opioids, such as fentanyl, are imported from China by ship (Bracken, 2017). It is important to note, however, that the current Canadian opioid crisis is a complex social problem driven by numerous factors, including mental health, homelessness, and physician prescribing practices. While marine shipping plays a role, it is obviously not responsible for this public health crisis.

While the precise volume of contraband flowing through Canadian ports is unknown, some of the largest cases of smuggling investigated by Canadian authorities have involved Canada's marine ports (Public Safety Canada, 2015). Ports and security forces, however, have taken actions to combat these threats. Enforcement measures found to be effective in the past include intelligence gathering, risk-based targeting, technology-based inspection, and manual searches by trained personnel (Public Safety Canada, 2015). In Canada, the RCMP's National Ports Strategy, National Port Enforcement Teams, and Waterfront Joint Forces Operation focus on investigating and preventing criminal activity in ports.

4.4.2 Increased foreign shipping activity in the Arctic may have implications for Canadian sovereignty and other impacts.

The Canadian Arctic consists of 162,000 kilometres of coastline and 40% of Canada's landmass (Global Affairs Canada, 2017; Government of Canada, 2017). The Canadian Arctic comprises approximately 25% of the global Arctic and Canadian sovereignty over this area is well established. It is based on the presence of Inuit and other Indigenous peoples for millennia, historic title, and international law (Carnaghan & Goody, 2006), although jurisdictional boundaries are not fully resolved (Côté & Dufresne, 2008). Canada also has a long history of collaborating with other Arctic nations, such as the United States and Norway (Carnaghan & Goody, 2006).

Concerns over sovereignty have escalated in recent years with increasing international interest in climate change, resource development, transportation access, and control of the Northwest Passage (Global Affairs Canada, 2017; Government of Canada, 2017). To the extent that the Northwest Passage opens the door to increased shipping activity as ice melts, Canada's assertion that it represents territorial waters will be

increasingly challenged (Carnaghan & Goody, 2006). Indeed, the United States has already suggested that the Northwest Passage constitutes international waters (Carnaghan & Goody, 2006). Increased marine shipping in the Arctic, Canadian or otherwise, will have a number of impacts: economic (e.g., resource exploration and extraction, infrastructure development); cultural (e.g., traditional Inuit ways of life); environmental (e.g., ecosystem degradation, fish and wildlife conservation); and security (e.g., shipping accidents, foreign shipping activity).

4.5 CONCLUDING REMARKS

Most Canadians benefit from the diversity and lower price of goods available in Canada and many Canadians benefit from the economic activity that goes hand in hand with international trade. Marine shipping plays a fundamental role in the economy, enabling specialized production and trade patterns. If Canada were limited to using other modes of transportation or U.S. ports, the country would be permanently and substantially less well off, by an amount equal to approximately 1.8% of Canadian GDP. This significant economic impact is overlooked when relying solely on the GDP of the Canadian shipping industry. Comprehensively assessing the economic impact of commercial marine shipping requires estimating how shipping affects the structure of the entire economy.

Marine shipping is also deeply embedded in Canada's culture, environment, and security, but its impacts in these areas are both positive and negative. On the one hand, most Canadians, particularly the industry's 99,000 workers, believe that shipping has played an important role in shaping their own identity and that of Canada. On the other hand, marine shipping adds to global GHG emissions, although less than other modes of transportation, and moves some illegal drugs and counterfeit goods into and out of Canada. Overall, when the vantage point shifts away from an exclusive focus on economic impact, the value of marine shipping reveals itself to be multidimensional. Data limitations, however, make it difficult to comprehensively assess the cultural, environmental, and security impacts.

5

Regional and Local Perspectives

- Economic Impacts
- Cultural Impacts
- Environmental Impacts
- Security Impacts
- Concluding Remarks

5 Regional and Local Perspectives

Key Messages

- Positive regional and local impacts arise from the economic activity associated with marine shipping and ports, and vary according to the structures of regional economies and the extent of shipping activity.
- Canada's marine shipping industry is a source of approximately 99,000 jobs, concentrated in its largest ports: Vancouver, Montréal, and Halifax. In some rural coastal communities, jobs related to marine shipping are a substantial source of local employment.
- Most negative impacts of shipping tend to be localized. These include air, noise, and light pollution, the introduction of invasive species, and other environmental impacts, most of which are declining due to more stringent regulation and ship and port initiatives.
- Shipping and ports are associated with security impacts including individual occupational health and safety risks, accidents, and potential threats from terrorism.
- Marine shipping can have distinctive impacts on Indigenous peoples, including disruptions in traditional, culturally important activities such as fishing and hunting.
- The balance of negative and positive impacts of marine shipping varies by location. Existing evidence typically does not allow for definitive assessments of its local or regional value because the negative impacts often are associated with non-market externalities that are difficult to monetize.

This chapter examines the localized impacts of marine shipping across the four dimensions of social value; these impacts vary across Canada. Similar to the national level, impacts are both positive and negative, and range from local employment opportunities associated with port facilities to adverse impacts on Indigenous culture.

5.1 ECONOMIC IMPACTS

5.1.1 The economic impacts of shipping vary according to the structures of regional economies.

Table 5.1 presents a variety of indicators showing how the economic impact of marine shipping varies by region. In Western Canada, for example, nearly one-quarter of all international trade (taking into account both goods by province of origin and imports by province of destination) is carried by ship. Relative to the size of the economy, this volume of trade is equal to approximately 8% of the region's GDP. The top three commodities by value exported by sea are fossil fuels (including coal and oil), pulp and paper, and wood products. Imports are dominated by M&E, electronics, and steel.

Table 5.1

Economic Impact of Marine Trade by Region in Canada, 2015

Region	Marine Exports		Marine Imports		Total Marine Trade ($B)	Marine Trade as Share (%) of Trade	Marine Trade as % of GDP
	Total ($B)	Top 3	Total ($B)	Top 3			
Western	27.8	• Oil/Coal • Pulp and paper • Wood products	21.9	• M&E • Electronics • Steel	49.7	24.0	8.1
Prairies	18.9	• Wheat • Canola • Produce	1.0	• M&E • Chemical products • Organic chemicals	19.9	25.5	13.5
Central	28.8	• Ore • Nickel • M&E	70.9	• Oil/Coal • M&E • Vehicles	99.7	13.9	9.1
Atlantic	17.8	• Oil/Coal • Ore • Fish	17.7	• Oil/Coal • Vehicles • M&E	35.5	70.2	32.1
Northern	0.03	• Ore • Fish • M&E	0.05	• Oil/Coal	0.08	3.8	0.8
Canada	93.4	• Oil/Coal • Ore • Wheat	111.6	• Oil/Coal • Vehicles • M&E	205.0	19.4	10.4

Data Source: Panel calculations based on Statistics Canada, 2015

The table presents data on the value of marine trade by the five regions identified in Chapter 1. The total value of all marine imports and exports for the region are identified in columns 2 and 4. The top three marine exports (column 3) and marine imports (column 5) are the most traded goods by dollar value. Column 8, marine trade as a % of GDP, is the ratio of marine trade to GDP. This is not the share of marine trade in GDP because these two metrics are calculated in different ways. This indicator is intended to highlight the size of marine trade relative to the size of the regional economy.

Different patterns of reliance on marine transportation are suggested by these figures. Atlantic Canada stands out as relying heavily on marine trade, largely due to its role in carrying exports of crude oil produced from Atlantic offshore platforms to the United States and other markets, and imports of crude oil to serve refineries in Atlantic and Eastern Canada. The Prairies are also notably dependent on marine shipping, despite their distance from the coasts, as agricultural products such as canola and wheat are often shipped overseas. The larger size of the economies of Central Canada ensures that the total values of goods shipped to

and from this region are high. The data also indicate the role of M&E imports in supporting Central Canada's manufacturing industries. Northern Canada is unique in its reliance on marine shipping. Exports of goods such as fish and ore highlight the role of resource extraction industries in the North; what is not visible here, however, is that northern communities are almost entirely dependent on marine shipping for annual provision of essential goods such as food, fuel, and construction materials (see Section 3.5).

5.1.2 Shipping is a source of local GDP and value added in port communities and surrounding areas.

As noted in Chapter 4, studies have suggested that marine shipping directly contributes around $3 billion in GDP. Including indirect and induced effects, estimates rise to between $5.5 and $9.1 billion. These impacts are primarily localized in coastal and port regions across Canada. They are the result of economic activity that occurs in ports or port cities, and secondarily, along the transportation and supply chains associated with marine shipping. In some port regions, such impacts can be substantial. For example, analysis by the Port of Montréal suggests that port activity translates into $2.1 billion in value added to the Canadian economy (Montreal Port Authority, 2015). In Montréal, the port is a central element in a larger logistics and transportation cluster that plays an important role in the local economy (KPMG, 2014). Similarly, the Port of Prince Rupert has estimated that, taking into account direct, indirect, and induced effects, it contributes around $680 million annually to the provincial economy (InterVISTAS, 2015). The Port of Halifax has been estimated to contribute $744 million in GDP to the regional economy (Halifax Port Authority, 2015). These estimates should be interpreted with caution given the methodological challenges involved in economic impact studies. However, they indicate that Canada's largest ports are major sources of GDP and value added for local and regional economies.

5.1.3 Marine shipping is a direct source of local employment in port communities and indirectly drives employment and economic development in some areas.

As reported in Chapter 4, national estimates suggest that shipping and related occupations account for upwards of 99,000 jobs in Canada. These jobs provide Canadians with a source of wages and have social and cultural importance in communities where the port accounts for a comparatively large share of employment. For example, an estimate commissioned by the Port of Prince Rupert (InterVISTAS, 2015) suggests that the port may now account for over 20% of total employment in the community, taking into account direct and indirect employment. In rural regions such as the Isthmus of Avalon in Newfoundland,

shipping-related employment opportunities are one of the dominant drivers of local economic activity and employment (Box 5.1). However, port-related employment is a small share of total employment in larger port cities. It is also declining over time in many locations due to increasing automation (see Section 6.1).

Box 5.1
Marine Shipping and Development on the Isthmus of Avalon, Newfoundland

The island of Newfoundland is highly dependent on marine shipping. During the 1950s and 1960s, the Liberal government under Joseph "Joey" Smallwood, the first Premier of the new Province of Newfoundland after Confederation with Canada in 1949, sought to diversify the resource-dependent province through industrialization. Smallwood focused his government's industrialization efforts largely on the Isthmus of Avalon Peninsula, which connects the easternmost part of the province, including the capital city of St. John's, to the rest of the island. The region's comparative advantages include several deepwater ports, a ready workforce, and proximity to the administrative centre of St. John's.

Smallwood's efforts, based mainly on attracting foreign capital through generous financial and other incentives, had mixed results. A phosphorus reduction plant was established at Long Harbour in the late 1960s, attracted mainly by low government-subsidized electricity rates. The plant operated for 21 years with peak employment of about 500, but it caused serious marine and terrestrial pollution problems and was eventually closed down in 1989. The second major project was a refinery near Come By Chance, but it failed under its first owners, leading to one of the largest business bankruptcies in Canadian history. Subsequently, the refinery was revived under new ownership and it continues to operate effectively today, employing over 600 people and producing 115,000 barrels of refined product per day (North Atlantic Refining LP, 2006). The North Atlantic refinery is totally dependent on marine shipping for importing its crude oil (the refinery was established long before Newfoundland's offshore oil industry went into production) and for exporting most of its refined product.

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Although subsequent governments were highly critical of Smallwood's industrial projects, they nevertheless followed his example by focusing several large-scale projects on the Isthmus of Avalon. During the 1980s, under Premier Brian Peckford and his Progressive Conservative government, a major fabrication site was established at Bull Arm for building the huge concrete gravity-based platform for Hibernia, Newfoundland and Labrador's first and biggest offshore oilfield. Currently, Bull Arm is the site for the construction of the offshore platform for the most recent oilfield, Hebron. During the 1990s, a major transhipment terminal was built at Whiffen Head, which, as of 2015, had handled over 2 billion barrels of Grand Banks crude oil. The most recent industrial project on the Isthmus, initiated under Liberal Premiers Brian Tobin and Roger Grimes, is a plant at Long Harbour, which will process nickel concentrate shipped by sea from Voisey's Bay in Labrador. The plant is expected to employ around 475 people at full production.

Together, these industrial projects have created a strong economic base for the Isthmus of Avalon region. All of them, and thereby the region itself, are totally dependent on marine transportation for their viability. These projects also provide a means of maintaining the rural culture and satisfying the lifestyles of residents. As sociologist Peter Sinclair's (1999) comparative research has shown, the Isthmus is similar to the Bonavista peninsula, which has been more dependent on the fisheries, and, more recently, tourism. Both areas continue to experience unemployment and outmigration, but, compared with the Bonavista peninsula, industries on the Isthmus of Avalon provide a more secure economic foundation for residents.

5.2 CULTURAL IMPACTS

As discussed in preceding chapters, marine shipping played an important role in the development of maritime culture and heritage in Canada. The Pacific region, the Great Lakes, Atlantic Canada, and the Arctic have distinct maritime cultures and traditions, cultures often represented in local maritime museums (e.g., Maritime Museum of the Atlantic, Vancouver Maritime Museum) and maritime-related culture events (e.g., Festival du Voyageur, Richmond Maritime Festival). Historically, different cultures interacted in port cities, resulting in various forms of cultural exchange. Port cities also have distinct sub-cultures, including those of longshoremen and mariners. In all of these ways, shipping has played a role in the establishment of local maritime cultures and identities.

5.2.1 Marine shipping can have distinctive impacts on Indigenous peoples in Canada.

Marine shipping can have distinctive impacts on Indigenous peoples in Canada in coastal areas, particularly the Pacific coast, arising from the effects on traditional and non-traditional marine fishing and hunting, and impacts on culturally and ecologically sensitive areas. At the Port of Prince Rupert, for example, recent expansion has created conflict and tension with local First Nations. The Lax Kw'alaams and Metlakatla bands challenged port expansion in court in 2006, arguing that they were not reasonably consulted and accommodated in development plans affecting an area to which they had Aboriginal rights and title. The conflict was eventually resolved by a new agreement between the bands and the federal government in 2011, including a commitment to provide additional funds for economic development and employment training for band members. Some members of the Lax Kw'alaams First Nation are opposed to the proposed construction of an LNG terminal on Lelu Island, due, in part, to concerns about potential environmental impacts on sensitive salmon-bearing areas near the mouth of the Skeena River (CBC News, 2015b).

In areas such as the Principe and Douglas channels (see Box 5.2) on British Columbia's north coast, increased marine shipping may present serious aesthetic, ecological, and cultural impacts that will diminish Indigenous communities' use of land and other resources. In material terms, increased marine traffic can disrupt and interfere with local community vessel movement and transportation. The risks associated with marine accidents are a major concern for many communities, particularly where spills of fuel oil, crude, or other petrochemicals could have a negative impact on coastal ecosystems relied on for harvesting food and for tourism (CCA, 2016). While such risks are often assessed as low, incidents such as the recent grounding of an oil barge near Bella Bella and a resulting fuel spill both highlight and amplify such concerns. Increased marine transportation can also disrupt culturally sensitive areas (e.g., *spanaxnox* for coastal Indigenous peoples). While such impacts may not be apparent to shippers, port authorities, and non-Indigenous communities, they can cause real harm to Indigenous communities and challenge pre-existing Indigenous coastal governance systems. Marine planning initiatives, such as the Marine Plan Partnership for the North Pacific Coast (MaPP, 2016) and the Pacific North Coast Integrated Management Area (PNCIMA, 2016), explicitly recognize and take these impacts into account.

Box 5.2
Cultural and Environmental Impacts of Tanker Traffic in Douglas Channel

Enbridge's proposed Northern Gateway pipeline project (rejected by the federal government in 2016) would have involved the construction of a twinned pipeline connecting oil sands production in Alberta with a marine terminal at Kitimat in British Columbia. Diluted bitumen was to be transported from Alberta to Kitimat in one pipeline and the other was to carry condensate from the coast to the interior. The resulting marine exports of oil would have led to approximately 440 tankers transiting through Douglas Channel per year (about 1.2 per day). En route, these tankers would have travelled past the coastal community of Hartley Bay and through the traditional territory of the Gitga'at First Nation whose members had opposed the project, due to concerns about potential impacts on the local environment, their community, and their culture (Gitga'at Nation, 2013).

The Gitga'at are a coastal people and fishing and harvesting seafood from the marine environment is central to their culture and identity. Traditional food sources make up more than 40% of their diet and include eulachon, salmon, crab, red laver seaweed, abalone, mussels, clams, prawns, Pacific halibut, cockles, rockfish, sablefish, and Pacific herring (Gitga'at Nation, 2013). Threats to traditional food harvesting practices are also perceived as potential threats to the integrity and sustainability of their culture. For the Gitga'at, the prospect of a world without traditional food harvesting has been described as "…losing your identity. It's like wiping out your mind… That's what it would do to our community. It would wipe out everything. It would wipe out our life as we know it" (Gitga'at Nation, 2013).

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With respect to the effects of tanker traffic in Douglas Channel, the Gitga'at concerns include:

- Operational spills, such as accidental discharges of fuel oil and bilge, leading to environmental impacts and potential public health problems;
- Increased wake activity on coastal areas and related impacts including shoreline erosion, movements of sand and marine sediment, and direct risks to individuals harvesting from wake waves and backwash;
- Effects of increased noise on fish species and marine mammals;
- Potential introduction of invasive species with consequent negative impacts on local species;
- Interference with local fishing activities, including increased risks to boaters, negative impacts on local fishing grounds, potential damage to fishing gear, and reduced commercial catches; and
- Reduced demand for tourism and related businesses in the area.

Gitga'at Nation (2013)

The Gitga'at also remain concerned about the potential impacts of a marine accident or oil spill in the area, and are still dealing with the ongoing impacts of past accidents and fuel spills on the environment and local marine resources. Any adverse impacts of tanker traffic in Douglas Channel on traditional food harvesting would likely have secondary, negative impacts for the Gitga'at including outmigration from the area, loss of social and human capital and social support networks, disruption of cultural identity, and attendant increases in social and personal stress.

Underwater noise from marine shipping can also affect fish and marine mammal species, which can create problems for Indigenous peoples fishing or hunting in or near the marine environment. In the Arctic, the passage of ice-strengthened ships and icebreakers can prevent hunters and fishers from getting to traditional hunting and fishing areas and potentially strand them on the ice. (As one response to this challenge, portable bridges are now being deployed in some areas such as Voisey's Bay to avoid stranding hunters and fishers on the ice.) Because of this and other concerns about how shipping may affect marine mammal populations, many communities in the Arctic view the prospect of increasing marine traffic in the Arctic with mixed emotions. Additional economic opportunities may be welcome, but there are substantial misgivings about the potential effects of additional shipping on culturally important activities such as hunting and fishing (Arctic Council, 2009).

5.3 ENVIRONMENTAL IMPACTS

Shipping and port operations often have environmental impacts not reflected in the commercial price of shipping. These impacts often have measurable costs and become the source of tensions between ports and adjacent communities. While localized negative impacts are particularly acute in the case of marine accidents such as oil spills (see Box 5.3), the analysis and discussion in this report are limited to impacts arising in the course of normal shipping and port operations. In contrast, CCA (2016) provides an assessment of marine accident risks and impacts in Canadian waters that are not associated with normal operations.

Box 5.3
Environmental Impacts of Shipping Accidents and Spills

This Panel was tasked with assessing the value of marine shipping in relation to the normal course of shipping operations. Risks and impacts associated with marine accidents and oil spills were therefore out of scope and not considered. These risks, however, were assessed and characterized in a recent CCA workshop report (CCA, 2016). It found that marine accident risks in Canadian waters are declining due to technological advances and improved regulatory regimes. When they occur, however, accidents involving the release of crude oil and fuels can result in large social and environmental costs. In particular, the impacts of oil spills in the natural environment can persist over long periods, and have adverse effects on many marine species, with consequent implications for the health of coastal ecosystems and potential impacts on human health in coastal communities. The severity of these impacts depends on factors such as time of year, location, cargo type, volume spilled, weather and environmental conditions, and the ways that nearby communities use the marine environment. Environmental and social impacts arising from marine accidents, however, can be mitigated through the adoption and implementation of appropriate risk management protocols. See CCA (2016) for a more thorough discussion of these risks and impacts.

5.3.1 Shipping and port operations are a source of local air pollution.

Compared with rail and trucking, shipping is a relatively fuel-efficient mode of cargo transportation. However, ship engines rely on either marine diesel or marine heavy fuel oil, fuels that typically have had much higher sulphur contents than transportation fuels used on land. Shipping and port operations remain a key

source of criteria air contaminants[40] such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM) in major port cities. These emissions have direct effects on human health. Elevated ambient PM levels are associated with negative health impacts including asthma, heart attacks, hospital admissions, and premature mortality (Corbett *et al.*, 2007). Short-term exposure to SO_2 emissions can result in respiratory damage and exacerbate conditions such as asthma. SO_2 can interact with other particles in the atmosphere, leading to increased PM concentrations. Ships are also a source of NO_x emissions. Studies estimate that around 15% of global NO_x emissions and 5 to 8% of global sulfur oxides (SO_x) emissions are attributable to oceangoing ships (Eyring *et al.*, 2005; Corbett *et al.*, 2007), though these shares have likely declined in recent years due to more stringent regulation.

The health impacts and costs of this air pollution can be substantial. A 2007 study estimates that PM pollution from marine shipping has led to 60,000 deaths a year globally and health costs of up to US$330 billion per year (Corbett *et al.*, 2007). Merk (2014) estimates that exposure to shipping-related emissions in the 50 largest ports in OECD countries is associated with external costs of approximately €12 billion per year.

Shipping emissions, however, are now subject to increasingly stringent regulations. The International Marine Organization (IMO) and advanced economies now recognize marine criteria air contaminant emissions as anomalous among transport sources. In 2010, an amendment to the *International Convention for the Prevention of Pollution from Ships* (MARPOL) designated portions of North American waters as Emission Control Areas (ECAs). Ships entering these waters must meet new stringent emissions standards for NO_x, $PM_{2.5}$, and SO_x levels (EPA, 2010). According to research from the U.S. Environmental Protection Agency, the North American ECA is expected to save more than 14,000 lives annually by 2020, and improve the respiratory health of some 5,000 people in Canada and the United States (OECD, 2014).

Ports have also adopted incentive schemes to mitigate air emissions, including incentives to reduce steaming speeds; differentiated port dues based on the size of the vessel or its emissions; truck retirement programs to encourage the retirement of older, more polluting vehicles; and increased rail transport (OECD, 2014). Montréal, for example, one of the first ports in Canada to undertake a

40 Criteria air contaminants are a group of frequently regulated pollutants associated with smog and acid rain. They include sulphur oxides (SO_x), NO_x, PM, volatile organic compounds (VOCs), carbon monoxide (CO), and ammonia (NH_3). Ground-level ozone and secondary PM may also be considered as criteria air contaminants in some cases as they are produced as byproducts of reactions among these other contaminants (Environment Canada, 2016).

comprehensive inventory of land-side and marine emissions (Lindner & McEwan, 2012), has adopted hybrid electric service and maintenance vehicles and replaced diesel locomotives with multiple generator locomotives. As a result of these and similar actions, SO_2, NO_x, and PM emissions from ports and shipping are expected to decline in the future.

5.3.2 Shipping produces other environmental impacts and associated health and social costs.

Ports and shipping activity have an impact on marine and aquatic environments in multiple ways. Dredging of harbours and channels can result in habitat disruption and degradation in marine and aquatic environments. Anchoring can affect habitat and increase the suspension of sediment in the water. Ship strikes can lead to the deaths of marine mammals and ship noise can disrupt their communication and migration. Ballast water transfers can cause the introduction of invasive species, which can compete with and displace native species, resulting in large shifts in aquatic ecosystems.

These environmental impacts have associated health and social costs. For example, the documented costs associated with the introduction of invasive species from ballast water exchanges and hull fouling are extensive. In the Great Lakes region, at least 170 invasive species have been introduced, 32 of which have been attributed to discharges of ballast water (Holeck *et al.*, 2004). Associated costs span multiple sectors ranging from tourism to power generation. Zebra mussel monitoring and management of water systems, power plant intakes, and industrial facilities using surface water was associated with hundreds of millions of dollars in annual control costs in the Great Lakes (GAO, 2002). Sea lampreys are another invasive species introduced into the Great Lakes, which resulted in large economic costs (Lovell *et al.*, 2006; Anderson Economic Group, 2012).

Shipping-related introductions of non-native species in Canadian waters, however, are now declining. Since 1993, mandatory Canadian and U.S. regulations governing ballast water exchange have required all foreign ballast water to be exchanged for mid-ocean saltwater (Bailey *et al.*, 2011). Since 2006, foreign vessels entering the Great Lakes, including those declaring no ballast on board, have been required to flush ballast tanks with mid-ocean saltwater to purge any residual ballast. As a result, documented introductions of invasive species have been declining in the Great Lakes since the early 1990s and no new invasive species were introduced between 2006 and 2011. The Great Lakes ballast water management program consequently is held up as a potential model for other jurisdictions (Bailey *et al.*, 2011).

Other environmental impacts of shipping are addressed in various ways. Risks to marine mammals from ship strikes can be mitigated through speed reduction and the strategic location of shipping lanes and marine-protected areas. The IMO is developing voluntary guidelines for minimizing underwater noise from ships. Canada has federal guidelines in place for mitigating underwater noise from seismic surveys and sonar, but there are no federal laws or standards regulating ocean noise from marine vessels (WWF, 2013). The Port of Vancouver, however, has voluntarily implemented an Enhancing Cetacean Habitat and Observation (ECHO) Program, which aims to better understand and manage the impacts of shipping activities on northern and southern resident killer whales throughout the coast of southern British Columbia (Port of Vancouver, 2016), and inform the development of mitigation and management approaches to quantifiably reduce threats from commercial vessels to at-risk whales (Port of Vancouver, 2015).

5.3.3 Port operations increase ambient noise levels and traffic congestion in local communities.

Noise from port operations, including ships, cranes, trucks, trains, and industrial activity, can be significant and cause conflict with nearby communities. In close proximity to auxiliary diesel engines for ships, noise levels can reach 80 to 120 decibels (a chainsaw, in comparison, averages 110 decibels) (Sharma, 2006; OECD, 2014). There has been little research done on community noise impacts related to ports in Canada. Surveys from the European Seaports Organisation repeatedly rank noise pollution among the five most important environmental impacts perceived by European ports (ESPO, 2013). The primary adverse impacts of port noise are annoyance and sleep disturbance, but it can also contribute to high-blood pressure, heart disease, and other stress-related symptoms (Sharma, 2006; OECD, 2014). Ports cause traffic congestion due to cargo moving to and from the hinterland to the port. Much of this cargo is moved by truck, which is an additional source of noise and air pollution. Congestion impacts from ports and shipping are a function of many factors, including the geographic layout of the port and major transit routes, port service models, infrastructure, storage and warehousing space, and efficiency of cargo loading and unloading (OECD, 2014). High truck volumes and large cargoes also have a disproportionately large impact on the occurrence of traffic accidents and associated delays.

Ports have other impacts on local communities. They can be a source of land-use conflicts due to their occupation of large areas of valuable waterfront real estate. They have a visual impact on the landscape and cityscape, with cranes, industrial facilities, and bulk cargo piles sometimes perceived as intrusive and unappealing. Ports can be a source of light pollution at night and of odours from industrial activity at or near the port (OECD, 2014). Port operations are a source of dust due to bulk cargo handling and storage, construction work, and road traffic, which can also exacerbate respiratory conditions (Fortescue, 2011).

Large modern ports, however, routinely take steps to mitigate these impacts and minimize sources of tension with nearby residents and communities. Such actions, often formalized through port sustainability plans, include performance measurement and verification according to third-party standards. For example, the Port of Montréal has a multipronged approach. Using Green Marine's data for 2014, as assessed by Walker (2016), the Port of Montréal's environmental performance relative to that of the other 16 participating Canadian ports reflects a commitment to managing impacts and reducing or eliminating potential sources of tensions with the neighbouring community (see Box 5.4). The 16 other Canadian ports participating in Green Marine have taken similar steps (Walker, 2016).

Box 5.4
Port of Montréal and Green Marine

Formed in 2007, Green Marine is an environmental certification program for the North American marine industry that uses environmental and social performance indicators to assess participating ship owners, ports, terminals, Seaway corporations, and shipyards. Participation is voluntary and requires self-evaluation according to standardized performance criteria. Port performance is assessed on GHG mitigation, spill prevention measures, community impacts, and environmental leadership.

Green Marine ratings for Montréal suggest that addressing social and environmental impacts is a priority. Figure 5.1 shows Montréal's ratings relative to the performance of 17 other Canadian participating ports. Scores on GHGs and environmental leadership reflect achievements prompted by the port's environmental policy (in place since 2001) and environmental management system. The port's score for community impacts indicates that it has taken action to mitigate noise, dust, and light pollution; implemented nuisance mitigation measures; developed relationships and involvement in local organizations; created permanent communication channels with the community to inform it about port activities and plans; and led a permanent consultative committee open to citizens (Green Marine, 2015). In Montréal's case, this last commitment was met through the creation of a Good Neighbour Committee in 2014 (Montreal Port Authority, 2014c). The port also provides financial support to organizations that help youth and families in neighbouring communities, and has allowed citizens access to green spaces such as Promenade Bellerive in Montréal's east and some parcels of land for the creation of a bike path near the river (Montreal Port Authority, 2014c).

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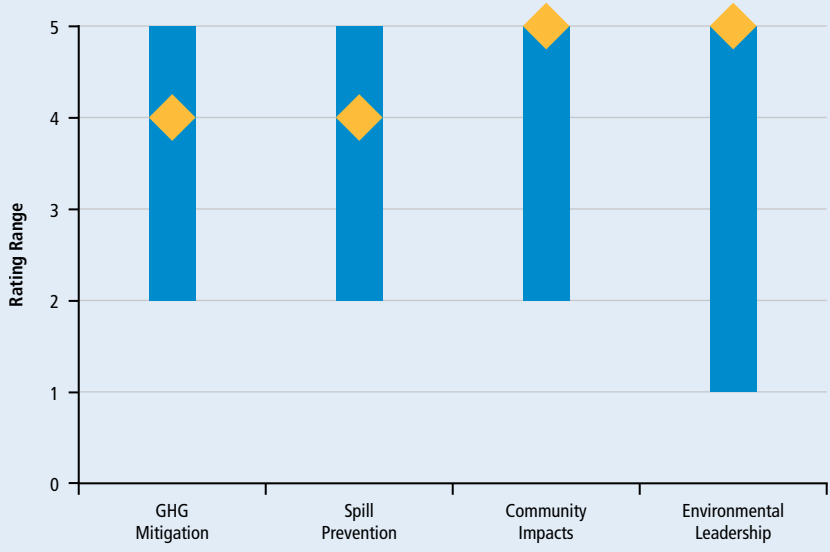

Data Source: Walker (2016) based on Green Marine 2014 data

Figure 5.1

Port of Montréal Green Marine Ratings Relative to 17 Participating Canadian Ports, 2014

Green Marine ratings are based on a categorical scale of 1 to 5, where 1 indicates active monitoring to ensure compliance with regulatory obligations and 5 indicates leadership and excellence in the area. Each score is associated with defined benchmarks and criteria. For example, for the community impacts indicator, to earn a level 4 rating, ports must "adopt measures to hold back dust on roads" and "direct lights so they only illuminate the necessary zone", among other things. The Port of Montréal (the yellow diamond) has consistently earned high scores on these indicators since Green Marine was started in 2007. The blue bar represents the range of ratings.

5.4 SECURITY IMPACTS

5.4.1 Marine shipping caused an average of 14 serious human injuries per year in Canada in 2011–2015.

Individuals employed in the marine shipping industry experience direct risks to their personal health and safety through occupational hazards. Working in freight transportation carries several distinctive risks related to the operation of heavy equipment and machinery, the movement of large volumes of cargo, and potential exposure to hazardous chemicals and materials. Mariners also face additional hazards associated with life on board a marine vessel including other accident risks, the risk of falling overboard or drowning, and heightened risks

associated with sanitation and communicable diseases given shared living quarters. U.S. statistics suggest that falls and falls into water are, respectively, the leading causes of morbidity and mortality in the industry (Weber, 2011). In Canada, cargo vessels were involved in 68 on-board accidents involving serious injuries between 2011 and 2015, and 8 fatalities. Fishing vessels and ferry and passenger vessels, however account for the large majority of marine accidents aboard ship in Canada (Transportation Safety Board of Canada, 2015). Most accidents in the marine shipping industry are associated with human factors. These occupational risks can be mitigated through carefully integrating anthropometric, cognitive, and behavioural factors in vessel operation, engineering and design, training, and work activities (Weber, 2011).

5.4.2 Port infrastructure used in the shipping and storage of hazardous materials pose local safety and security issues.

Ports are also linked to a number of localized safety and security issues due to their status as a potential vector for hazardous materials or illicit goods entering the country (OECD, 2014; Public Safety Canada, 2015). Hazardous materials stored on ships or in port facilities can threaten the safety of workers, and incidents involving improper handling or storage of these materials have led to accidents and worker fatalities internationally (OECD, 2014). Such materials include a wide range of chemicals, petroleum products and fuels, and some consumer goods such as batteries. Facilities on or near ports, such as fuel tanks, chemical plants, power plants, and oil refineries, also represent potential security threats to local communities through either accidental failures or as targets for terrorist attacks. Since the attacks on September 11, 2001, ports and security agencies have been increasingly concerned about the risk of a weapon of mass destruction being shipped into a country and detonated at a port (OECD, 2014). In Canada, Bill S-7, *Combating Terrorism Act* (Government of Canada, 2013), focused on strengthening Canada's port security efforts. At multiple levels, Canadian agencies (including the Canada Border Services Agency) have worked jointly with U.S. agencies to identify and intercept threats.

5.5 CONCLUDING REMARKS

Commercial marine shipping can be a source of substantial regional and local economic benefit, providing employment opportunities and supporting local industries where other opportunities are lacking. In the Canadian context, the significance of these opportunities is evident in major port cities and in coastal communities such as Prince Rupert and Come By Chance, where shipping-related employment plays a vital role in local economies.

Shipping also has adverse localized impacts on culture, environment, and security. In terms of culture, shipping affects Canada's Indigenous peoples in unique ways, disrupting or threatening traditional activities such as fishing and hunting and altering the coastal environment. The severity of most environmental impacts, including localized air, noise, and light pollution and increased traffic congestion, is now declining in response to more stringent regulation and greater industry awareness; however, the impacts still offset shipping's economic benefits. Shipping and ports are also associated with security impacts including individual occupational health and safety risks, accidents, and potential threats from terrorism.

Overall, the Panel concludes that adverse impacts must be considered in future planning and that an economic impact approach is not the only way to assess the value of shipping to Canada.

6

Trends that May Affect Future Shipping Activity in Canada

- Trends that May Increase Shipping Activity
- Trends that May Decrease Shipping Activity
- Concluding Remarks

6 Trends that May Affect Future Shipping Activity in Canada

Key Messages

- Global population and income growth will increase global trade, which in turn will substantially increase Canadian marine shipping activity.
- Trade liberalization, growing oil production, climate change, and technological progress in marine shipping have the potential to increase shipping activity in Canada.
- Information technology, geopolitical movements, slowing coal production, and local environmental and safety concerns have the potential to decrease shipping activity in Canada.
- The overall effect of global and domestic social trends will likely increase future marine shipping activity in Canada.

Until about 200 years ago, marine transportation was the only way to move large volumes of agricultural products, natural resources, and manufactured goods over long distances (Diamond, 1997; Harari, 2014). Today, in an information-driven economy and with a range of alternative modes of long-distance travel, marine shipping remains a valuable service, equal to about 1.8% of the Canadian economy.

Marine shipping is subject to a range of global forces, including population and income growth, scientific and technological progress, environmental and ecological change, and cultural and political evolution. The direction and size of these forces shape the type of society in which trade and its impacts exist. By shaping trade, they also shape the demand for marine and other modes of transportation. This chapter assesses the potential effects of the numerous trends that the Panel judged to be most significant for commercial marine shipping: population and income growth, global trading behaviour, technological progress, energy production, climate change, and local environment and safety.

6.1 TRENDS THAT MAY INCREASE SHIPPING ACTIVITY

Table 6.1 considers the relationship between trends and future shipping activity, providing a qualitative estimate of the relative size of these effects.

Table 6.1

Trends that May Increase Marine Shipping Activity in Canada

Trend	Magnitude	Description
Global Population and Income Growth	High	Greater demand for Canadian dry and liquid bulk commodities and general cargo will increase marine exports and imports.
Trade Liberalization	Moderate	More trade with non-U.S. countries will increase marine exports and imports. Production offshoring will increase.
Oil Production	Moderate	This will increase marine exports and imports of oil and natural gas.
Climate Change	Low	Less Arctic sea ice due to climate change is opening up new opportunities for shipping in the Arctic but may also affect Arctic resupply. The relative cost of marine shipping will decline under carbon pricing (for all modes of transport).
Technological Progress	Low	This will lower shipping costs and environmental impact due to information technology and ship size. This may potentially decrease employment in the marine shipping industry given greater automation.

The table presents five trends that may increase future marine shipping activity. The estimates of magnitude are qualitative and comparative in nature. The Panel does not intend these to be precise in a quantitative sense. Effects are considered in isolation from the other trends (i.e., holding all else equal).

Most estimates of the global economy (Gros & Alcidi, 2014) project significant economic growth over the next 20 to 30 years, with some suggesting as much as a doubling by 2037 and near tripling by 2050 (PwC, 2015). *Global population and income growth* will be driven by developing economies in Asia, Africa, and the Middle East. This growth will increase global demand in dry (e.g., wheat, iron ore) and liquid (e.g., oil, LNG) bulk commodities (UNCTAD, 2015). Rising global incomes, in particular, are likely to increase the demand for general cargo, including vehicles, consumer goods, M&E, and intermediate imports. Population and income growth is likely to substantively increase marine shipping activity.

The evidence that modern capitalism has improved material standard of living is compelling. In 1500, annual per capita production averaged $550, while today it is nearly $9,000 per year (Harari, 2014). There is also convincing evidence that modern capitalism has been central to increased life expectancy, scientific and technological progress, and positive cultural and political evolution (e.g., women's employment, more democracies, fewer wars) (Harari, 2014). Proponents of *trade liberalization* often point to free trade as furthering the positive impacts of modern capitalism. While the fate of the Trans-Pacific Partnership is unclear, it is likely that Canada will continue to liberalize its trade. For example, Canada has signed six new trade deals over the last five years, including the recently signed Canada-European Union Comprehensive Economic and Trade Agreement (CETA), and is engaged in ongoing negotiations with other major trading countries such as China, Japan, and India. This trend is likely to increase marine shipping activity.

Crude *oil production* in Canada is projected to increase by 83% to 6.4 million barrels per day by 2030 (CAPP, 2014; CPCS, 2015). The share of marine crude oil exports to China is projected to grow to 52% by 2045 (CAPP, 2014; CPCS, 2015). As most of this projected production increase is from the oil sands, advances in oil sands technology will be important (CCA, 2015). The recently approved Trans Mountain Expansion Project (November 2016) will improve access to China and other Asian markets and increase shipping activity in Vancouver. The rejection of the Northern Gateway Pipelines project is likely to halt shipping activity in the ecologically sensitive Great Bear Rainforest. Further production of coal, offshore oil, and natural gas will increase marine shipping activity.

As discussed in Chapters 4 and 5, *climate change* has the potential to increase marine shipping, particularly in the Arctic. The physical environment of the Arctic is currently experiencing some of the most rapid environmental changes of all regions globally (Derksen *et al.*, 2012; Jeffries *et al.*, 2013).[41] This has significant implications for marine shipping including opportunities related to trade, development, tourism, and natural resource development (Guy, 2006; Prowse *et al.*, 2009; Dawson *et al.*, 2014; Lasserre & Têtu, 2015). These recent changes have caused speculation about the region's utility as a major trading route connecting Asia and North America, given the potential distance and cost savings over routes through the Panama and Suez Canals

41 There has been a shift from a predominantly thick perennial Arctic sea ice regime to a younger, thinner, and more seasonal sea ice regime that is more conducive to ship navigation and has significantly extended the shipping season (Parkinson, 2014; Comiso, 2012; Maslanik *et al.*, 2011). For example, multi-year ice coverage declined by 83% between 2002 and 2009 in the Canadian sector of the Arctic Ocean (Maslanik *et al.*, 2011), and the pan-Arctic melt season length increased by an average of five days per decade from 1979 to 2013 (Stroeve *et al.*, 2014).

(Guy, 2006; Somanathan *et al.*, 2007; Khon *et al.*, 2009; Stephenson *et al.*, 2011; Lasserre & Têtu, 2015). Despite these enticing savings, hazards such as multi-year ice and icebergs (Kubat *et al.*, 2007; Van Wychen *et al.*, 2014; Howell *et al.*, 2015) make the region arguably more dangerous to navigate and certainly less reliable. Arctic shipping also has higher financial costs than conventional shipping, including higher insurance premiums, manufacturing of ice-strengthened vessels, hiring trained ice pilots, and ice-breaking support services (Arctic Council, 2009; Hodgson *et al.*, 2013). These financial risks are further exacerbated by physical risks due to the lack of marine infrastructure to support shipping operations such as the lack of deepwater port facilities, limited locations for refuelling, challenges with access to search and rescue services, and poorly charted waters (Arctic Council, 2009; Hodgson *et al.*, 2013). Despite the lengthened open-water shipping season and increased traffic, a drastic increase in ship activity in the region is unlikely in the near to medium term.

Climate change policies may affect the costs of marine shipping relative to other modes of transportation. More stringent GHG mitigation policies, such as carbon pricing, make marine shipping relatively less expensive because it is the least emissions-intensive mode of freight transportation. By decreasing the relative costs of marine shipping, climate change policies may increase marine shipping activity. However, if carbon pricing reduces economic production or substitution from other modes is not possible, this effect will be limited.

Technological progress will continue to lower marine shipping costs and environmental emissions. Automated systems on ships improve operational performance and safety (DNV GL, 2014). Ship design will be increasingly driven by computing power and artificial intelligence, enabling better hull and propulsion design, for example. Autonomous vessels will lower operational costs, reducing the number of crew and human error (DNV GL, 2014). They may also revolutionize supply chain logistics and travel more energy-efficiently than other vessels (UNCTAD, 2015). While the limits of ship size were reached in the bulk sector in the 1980s, the limits of economies of scale have not been reached in the container sector. Since the container revolution that began in 1956 with the *Ideal X* (Levinson, 2008; Bernhofen *et al.*, 2016), the size of container ships has increased dramatically (UNCTAD, 2015), although this trend appears to be slowing.[42]

42 This trend has led to greater concentration in the container shipping market. As UNCTAD (2015) highlights, while container-carrying capacity per company per country tripled in 2004–2015, the average number of companies decreased by 29%. Ultimately, as ships get larger and companies aim to achieve economies of scale, the number of companies decreases (UNCTAD, 2015). Despite this growing industrial concentration, the container shipping industry has been highly unprofitable over the past five years (Boston Consulting Group, 2014; Glave *et al.*, 2014).

6.2 TRENDS THAT MAY DECREASE SHIPPING ACTIVITY

Table 6.2 considers trends that may decrease future shipping activity in Canada. Similar to Table 6.1, it provides a qualitative estimate of magnitude, with all effects considered in isolation (i.e., holding all else equal).

Table 6.2

Trends that May Decrease Marine Shipping Activity in Canada

Trend	Magnitude	Description
Increase Use of Information Technology	Moderate	Data are not moved by physical modes of transportation. This will lead to slower growth in marine exports and imports.
Geopolitical Movements	Moderate	This may lead to a potentially slower pace, or even a stall, in trade liberalization efforts. This will lead to a decrease in marine exports and imports, and less production offshoring.
Change in Coal Production	Moderate	This will lead to a decrease in marine exports of thermal coal.
Local Environmental and Safety Concerns	Low	Marine shipping moratoriums and pipeline rejections. Greater attention paid to the impact on Indigenous peoples.

The table presents four trends that may decrease future marine shipping activity. The estimates of magnitude are qualitative and comparative in nature. The Panel does not intend these to be precise in a quantitative sense. Effects are considered in isolation from the other trends (i.e., holding all else equal).

The importance of marine shipping to the goods sector is generally undisputed. As highlighted in Chapters 2 through 5, marine shipping is often essential for moving large volumes of bulk commodities (e.g., wheat, oil) to non-U.S. countries. However, in 2016, the services sector comprised more than three-quarters of the economy, including health care, education, and finance. The value of marine shipping is more difficult to establish for this side of the economy. The productivity-enhancing imports (such as computers, information and communication technologies (ICT) equipment, and other large advanced technologies) that marine shipping transports to Canada support service industries, which are increasingly information-driven. As *information technology* continues to expand, however, data, which move by communication networks rather than by physical modes of transportation, will become the central commodity of the future economy. Indeed, global data flows more than doubled between 2013 and 2015 alone, reaching 290 terabytes. In Canada, the value of data flows was estimated at $1.4 trillion in 2014 (MGI, 2016). Some advances in information technology, such as artificial intelligence and biotechnology,

may have even profounder impacts on the economy and human society overall, which are difficult to assess (Kaku, 2011; Bostrom, 2014; Harari, 2016). To the extent that the service sector and especially information-driven economic activity expands, growth in marine trade may slow. The absolute amount of marine shipping activity is still likely to increase.

The evidence that modern capitalism has led to income inequality in developed countries is compelling. Since the 1970s, income growth has become increasingly concentrated in the top 10% of the population (Piketty, 2013). Evidence also shows that modern capitalism has led to ecological degradation, human exploitation, and negative cultural and political change (e.g., consumerism, political corruption) (Harari, 2014). Critics of trade liberalization often point out that free trade exacerbates the negative impacts of modern capitalism. These concerns have risen to prominence again, with the rise of both social justice and nationalist movements. While driven by profoundly different value systems, these *geopolitical movements* have the potential to slow or even reverse trade growth. However, the combined impact of population and income growth alone is likely to be large enough that marine shipping activity will still increase.

Global and national concerns about the environmental impact of fossil fuel production and consumption (and technological progress in clean energy) will likely decrease the global demand for thermal coal (CCA, 2015b). Declining thermal *coal production* will decrease marine shipping activity. Similarly, to the extent that oil sands bitumen, which has a large environmental impact relative to other types of oil (CCA, 2015), is viewed unfavourably both in Canada and abroad, its production may also slow. This would also decrease marine shipping activity in Canada.

The impact of oil spills and other shipping accidents can be significant (CCA, 2016). *Local environmental and safety concerns* will affect the social desirability of specific operations and political decisions around modes of transportation (CCA, 2016), as demonstrated by the rejection of the Northern Gateway Pipelines project and the crude oil tanker moratorium in British Columbia. These concerns may also prevent the construction of the Energy East Pipeline project, which could limit future crude and refined oil export growth in Atlantic Canada, and continue Canada's dependence on crude oil from Africa, Europe, and the Middle East. Land claims and their impact on the socioeconomic conditions of Indigenous peoples are likely to play a more prominent role in resource management in Canada. On balance, these trends could decrease shipping activity in Canada.

6.3 CONCLUDING REMARKS

Marine shipping provides a valuable service, cheaply moving large volumes of goods over long distances. However, marine shipping is no more responsible for the trade it carries than trade is for the powerful global forces of population and income growth, scientific and technological progress, environmental and ecological change, and cultural and political evolution. Support for or opposition to marine shipping is more about one's perspective on these forces — that is, one's values — than about marine ships, per se. For example, as described above, competing perspectives on the impact of modern capitalism influence, sometimes significantly, perspectives on global trade and therefore on marine shipping.

Specific trends in these global forces will affect marine shipping. Global population and income growth will almost certainly increase global trade. It is likely that Canada will continue both to liberalize its trade and produce fossil fuels, although that could change in response to global economic and geopolitical trends. To some extent, these trends will be balanced by structural economic changes, political movements, and environmental and safety concerns. In the Panel's view, however, the overall effect of these trends will likely increase future marine shipping activity in Canada.

7

Conclusions

7 Conclusions

Marine shipping has been a feature of human exploration, trade, and conquest since the earliest days of human civilization. By moving goods and people, marine shipping has been involved in trade, war, colonialism, immigration, and two waves of globalization. These are the outcomes of complex human societies, however, and cannot be attributed solely to marine shipping. They are the result of countless additional factors, with shipping playing only a facilitating role. The Panel believes that it is important to keep this in mind when considering the value of marine shipping.

This historical role obviously does not imply that marine shipping lacks value. Even today, in an information-driven economy and while competing with four other modes of long-distance travel, marine shipping remains a valuable service, equal to about 1.8% of the Canadian economy. While negative local impacts on the environment and security are in some cases sizable, marine shipping is the least GHG emission-intensive mode of transportation, a property that will become increasingly valuable in a world where carbon is priced. Marine shipping is also an important part of Canada's Arctic sovereignty and overall culture despite concerns about its impact on culturally important ecological areas and ways of life.

Marine shipping is more than just a conduit for connecting Canadians to the world outside of North America. Indeed, for some types of goods, there is no viable alternative to either getting them to market or receiving them from abroad. This collective enterprise plays a central role in Canada's collective social well-being. The evidence bears this out. When assessed in totality and from all angles — considering economic, cultural, environmental, and security impacts at the national, regional, and local levels — the net overall value of marine shipping to Canada is positive and sizable.

The Panel's five main conclusions are summarized below.

By moving goods and people, marine shipping has played a formative role in Canada's history. Today, despite other competing modes of commercial transportation, marine shipping remains an important part of Canada's economy and culture.

Indigenous marine trade existed for millennia before European settlement. Long-standing Indigenous trade routes traversed inland and coastal waterways. Canoes, kayaks, and other vessels were used to move a range of goods, including animal hides, fish, and shell ornaments. To facilitate early trade, colonial

settlers relied upon local Indigenous knowledge and the location of Indigenous communities along these established trade routes. These sites became some of the first commercial ports, and marine trade expanded.

As the only way to move large volumes of goods over long distances, marine shipping was essential to this expansion. Canadian staples, such as fur, fish, and timber, flowed to Europe and commodities such as cloth, guns, and luxuries flowed in return. The fur trade of Central Canada and the cod fishery in Atlantic Canada flourished. Major Canadian cities, like Montréal and Halifax, and numerous other coastal communities, have their origins in this early marine shipping activity. The extraction and export of staples was central to Canada's early economic growth and political development, but the resulting economic activity also contributed to over-fishing, forest degradation, and biodiversity loss. This growing marine trade disrupted and displaced Indigenous transportation and trade networks, and ways of life. By moving people, marine ships contributed to the spread of European disease and conflict and facilitated colonization, both of which led to widespread depopulation of Indigenous peoples.

Today, tankers, cargo ships, and other vessels move about 20% of Canada's trade. In 2015, the monetary value of this marine trade was $205 billion. This trade effects virtually every industry, region, and community across the country, although some more so than others. For most resource industries, such as oil, coal, iron ore, and wheat, commercial marine shipping is a central mode of transportation. For some manufacturing industries, marine shipping is equally as important, moving a range of machines and intermediate inputs for use in production. For most regions and communities, resource and manufacturing industries play a key role in their economies.

Despite other modes of commercial transportation, marine shipping remains tightly woven into Canada's cultural symbols, beliefs, and identity. Shipping-related icons such as the canoe, *Bluenose*, and *Amundsen* are among Canada's national symbols. Most Canadians believe that they are citizens of a maritime or seafaring nation and that marine shipping is an important part of Canada's culture. Today, commercial ships transport a diverse range of goods, including vehicles, furniture, clothing, electronics, and other consumer products. The consumption of these goods helps define the identities of most Canadians and plays a role in Canadian culture.

The GDP of Canada's marine shipping industry is about $3 billion. The positive national economic impact of commercial marine shipping, however, is estimated at approximately $30 billion due to its role in facilitating international trade.

Often, the economic impact of commercial marine shipping (and other industries) is measured by GDP. By this measure, the size of the domestic marine shipping industry in Canada is approximately $3 billion. Measuring the value of marine shipping by GDP, however, fails to capture the full national economic impact of marine shipping, which is derived from its role in facilitating international trade.

By moving goods to and from international markets, marine shipping enables specialized production and trade patterns that would be less efficient or perhaps not exist otherwise. The Panel commissioned a quantitative trade model to estimate the economic impact of marine shipping when these patterns are factored in. Estimates from this model suggest that in 2016 the national economic impact of commercial marine shipping was approximately $30 billion (1.8% of real Canadian GDP), which is about nine times larger than the industry's GDP and approximatively the current size of the economy of New Brunswick or Winnipeg.

The negative environmental impacts of marine shipping in Canada are mostly declining. Commercial marine shipping produces only 1% of Canada's GHG emissions.

Environmental impacts associated with commercial marine shipping include localized air and water pollution, effects on marine ecosystems and species, port-related noise and light pollution and traffic congestion, the introduction of invasive species, and risks arising from marine accidents and spills. The magnitude and costs of these impacts can be significant where they occur; however, many of these impacts are now declining in response to new regulations and port initiatives. Localized air pollution associated with shipping is declining in response to the creation of ecosystem controlled areas, for example, and the rates of introduction of invasive species into the Great Lakes have fallen since the introduction of new regulations governing ballast water exchange. Ports are also increasingly engaging with local communities to mitigate concerns over port-related noise and traffic, and other local community concerns.

Commercial marine shipping also has a global environmental impact by contributing to climate change through GHG emissions. In Canada, marine shipping produced 6.7 Mt of GHG emissions in 2013, accounting for 8% of the commercial transportation total, or about 1% of total Canadian GHG emissions.

Marine shipping remains the least GHG emission-intensive mode of commercial transportation. The emission intensity (i.e., GHG emissions per tonne-km) of the global industry will likely continue to decline as vessels become more efficient and use lower-carbon fuels.

The regional and local impacts of marine trade and shipping employment are unevenly distributed across Canada. Some negative cultural, environmental, and security impacts tend be concentrated locally.

Marine shipping is a central model of transportation for industries across Canada. The impact of these industries in Canada's regions and communities is uneven due to their different economic structures. For example, the metallurgical coal industry in Western Canada and the wheat and canola industry in the Prairies depend on marine shipping for export to Asia and other markets outside of North America. Atlantic Canada is dependent on marine shipping for exporting oil to the United States and importing it from Africa, the Middle East, and Europe. Manufacturing industries in Central Canada rely on marine shipping to access global supply chains. Intermediate imports are often carried by ship to Canadian firms, later to be re-exported as final goods, often to the United States. Within Canada, regional marine trade is in a small number of bulk commodities, such as forest products, iron ore, and crude oil, which are used in manufacturing industries. Finally, for some island, remote, and northern communities, marine shipping is vital for access to essential food, fuel, and machinery. Marine trade, both international and domestic, is a source of employment across Canada.

Canada's marine shipping industry itself is also a direct and indirect source of some 99,000 jobs across the country. In some coastal regions and port communities, jobs related to marine shipping are a substantial source of local employment and of approximately $4.6 billion in labour income. These jobs come with direct safety risks. Between 2011 and 2015, 68 on-board accidents and 8 fatalities were associated with this industry. The social significance of marine-related employment, however, is not fully reflected in simple employment or safety metrics. Employment is a critical component of individual identity and to the organization of social life in regions and communities.

As noted, many negative environmental impacts of shipping tend to be localized, arising in response to port and shipping operations. These impacts can be particularly acute for Indigenous peoples. Marine shipping may damage culturally and ecologically sensitive coastal areas and disrupt traditional fishing and hunting.

In the Arctic, the passage of commercial marine ships, icebreakers, and research vessels can sometimes prevent hunters and fishers from getting to traditional areas, potentially stranding them on the ice and affecting marine mammal populations. As ice melts in the Northwest Passage, the resulting increase in shipping activity will have an impact on Canada's Arctic sovereignty and communities.

Illegal drugs and counterfeit goods enter Canada by all modes of transportation, including by ship. While the precise volume of contraband flowing through Canadian ports is unknown, some of the largest cases of smuggling investigated by Canadian authorities have involved marine ports. Like most significant large-scale infrastructure, infrastructure at or near ports could also be a potential target for a terrorist attack.

Commercial marine shipping is evolving in response to global and domestic social trends. The overall effect of these trends will likely increase future shipping activity in Canada.

Global social forces determine the arrow of human history, including population and income growth, scientific and technological progress, environmental and ecological change, and cultural and political evolution. By shaping the societies in which trade occurs, these forces also influence marine and other modes of transportation. Global population and income growth will almost certainly increase global trade. Canada will likely continue both to export fossil fuels and liberalize trade, although that could change in response to global economic and geopolitical trends. To some extent, these trends will be balanced by structural economic changes, political movements, and environmental and safety concerns. In the Panel's view, however, the overall effect of these trends will likely increase future marine shipping activity in Canada. Whether this is to be judged as positive or negative depends, in part, on one's perspective on these forces — that is, on one's values.

References

References

Adney, E. T. & Chapelle, H. I. (2014). *Arctic Skin Boats*. New York (NY): Skyhorse Publishing.

Akerlof, G. A. & Kranton, R. E. (2010). *Identity Economics: How Our Identities Shape Our Work, Wages, and Well-Being*. Princeton (NJ): Princeton University Press.

Albert, K. & Weeden, K. (2011). Occupations and Professions. In *Oxford Bibliographies in Sociology*. Oxford, United Kingdom: Oxford University Press.

Anderson Economic Group. (2012). *The Costs of Aquatic Invasive Species to Great Lakes States*. East Lansing (MI): AEG.

Anderson, J. E. & van Wincoop, E. (2004). Trade costs. *Journal of Economic Literature, 42*(3), 691-751.

Angus Reid Institute. (2016). Canadians feel confident that marine shipping is safe, but they have reservations about transporting oil. Retrieved July, 2016, from http://angusreid.org/marine-shipping/.

Arctic Council. (2009). *Arctic Marine Shipping Assessment 2009 Report*. Tromsø, Norway: Arctic Council.

Autor, D. H., Dorn, D., & Hanson, G. H. (2016). The China shock: Learning from labor market adjustment to large changes in trade. *National Bureau of Economic Research Working Paper Series, No. 21906*.

Bailey, S. A., Deneau, M. G., Jean, L., Wiley, C. J., Leung, B., & MacIsaac, H. J. (2011). Evaluating efficacy of an environmental policy to prevent biological invasions. *Environmental Science & Technology, 45*(7), 2554-2561.

Bank of Canada. (2017). $50 Polymer Note. Retrieved January 2017, from http://www.bankofcanada.ca/banknotes/bank-note-series/polymer/design/50-polymer-note/.

Bernhofen, D. M., El-Sahli, Z., & Kneller, R. (2016). Estimating the effects of the container revolution on world trade. *Journal of International Economics, 98*, 36-50.

Bhagwati, J. (1995). Trade liberalisation and 'fair trade' demands: Addressing the environmental and labour standards issues. *World Economy, 18*(6), 745-759.

Boston Consulting Group. (2014). *Restoring Profitability to Container Shipping*. Boston (MA): Boston Consulting Group.

Bostrom, N. (2014). *Superintelligence: Paths, Dangers, Strategies*. Oxford, United Kingdom: Oxford University Press.

Bowles, S. (1998). Endogenous preferences: The cultural consequences of markets and other economic institutions. *Journal of Economic Literature, 36*, 75-11.

Broda, C. & Weinstein, D. (2004). Variety growth and world welfare. *American Economic Review, 94*(2), 139-144.

Brooks, M. R. & Hodgson, J. R. (2005). The Fiscal Treatment of Shipping: A Canadian Perspective on Shipping Policy. In K. Cullinane (Ed.), *Shipping Economics*. Amsterdam, Netherlands: Elsevier.

Brooks, M. R. (2011). Competition and Regulation in Maritime Transport. In A. de Palma, R. Lindsey, E. Quinet & R. Vickerman (Eds.), *Handbook of Transport Economics*. Cheltenham, United Kingdom: Edward Elgar.

Brooks, M. R. & Frost, J. D. (2012). Providing freight services to remote arctic communities: Are there lessons for practitioners from services to Greenland and Canada's northeast? *Research in Transportation Business & Management, 4*, 69-78.

Caliendo, L. & Parro, F. (2015). Estimates of the trade and welfare effects of NAFTA. *The Review of Economic Studies, 82*(1), 1-44.

Canadian Polar Commission. (2014). *Housing in the Canadian North: Recent Advances and Remaining Knowledge Gaps and Research Opportunities*. Ottawa (ON): Canadian Polar Commission.

Canadian Tire. (2010). Canadian Tire's Business Sustainability Strategy Drives Innovation, Profitability and Business Growth. Retrieved January 2017, from http://corp.canadiantire.ca/EN/CorporateCitizenship/Documents/Sustainability%20Release%20Q2%202010.pdf.

Canadian Tire. (2016). Fast Facts. Retrieved January 2017, from http://corp.canadiantire.ca/EN/AboutUs/Pages/FastFacts.aspx.

CAPP (Canadian Association of Petroleum Producers). (2014). *Crude Oil Forecast, Markets & Transportation*. Calgary (AB): CAPP.

Carlos, A. M. & Lewis, F. (2010). *Commerce by Frozen Sea: Native Americans and the European Fur Trade*. Philadelphia (PA): University of Pennsylvania Press.

Carnaghan, M. & Goody, A. (2006). *Canadian Arctic Sovereignty*. Ottawa (ON): Library of Parliament.

CBC News. (2015a, May 28). Iqaluit MLA Makes Case for Hydroelectric Power, *CBC*.

CBC News. (2015b, November 12). Lelu Island LNG Project Divides First Nations as Protest Continues, *CBC News*.

CCA (Council of Canadian Academies). (2009). *Innovation and Business Strategy: Why Canada Falls Short*. Ottawa (ON): Expert Panel on Business Innovation, CCA.

CCA (Council of Canadian Academies). (2014). *Aboriginal Food Security in Northern Canada: An Assessment of the State of Knowledge*. Ottawa (ON): Expert Panel on the State of Knowledge of Food Security in Northern Canada, CCA.

CCA (Council of Canadian Academies). (2015). *Technological Prospects for Reducing the Environmental Footprint of Canadian Oil Sands*. Ottawa (ON): The Expert Panel on the Potential for New and Emerging Technologies to Reduce the Environmental Impacts of Oil Sands Development, CCA.

CCA (Council of Canadian Academies). (2015b). *Technology and Policy Options for a Low-Emission Energy System in Canada*. Ottawa (ON): The Expert Panel on Energy Use and Climate Change, CCA.

CCA (Council of Canadian Academies). (2016). *Commerical Marine Shipping Accidents: Understanding the Risks in Canada*. Ottawa (ON): CCA

Clarksons Research. (2016). Shipping Intelligence Network. Retrieved July 2016, from https://sin.clarksons.net/.

Coates, K. (1982). Furs along the Yukon: Hudson's Bay Company — Native trade in the Yukon River Basin, 1830-1893. *BC Studies 55*, 50-78.

Conference Board of Canada. (2012). *Adding Value to Trade Measures: Understanding Canada's Role in Global Value Chains*. Ottawa (ON): Conference Board of Canada.

Congressional Research Service. (2014). *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*. Washington (DC): Congressional Research Service.

Corbett, J. J., Winebrake, J. J., Green, E. H., Kasibhatla, P., Eyring, V., & Lauer, A. (2007). Mortality from ship emissions: A global assessment. *Environmental Science & Technology, 41*(24), 8512-8518.

Côté, F. & Dufresne, R. (2008). *The Arctic: Canada's Legal Claims*. Ottawa (ON): Library of Parliament.

CPCS. (2015). *Impact of Future Bulk Commodity Flows on the Canadian Transportation System*. Ottawa (ON): Prepared by CPCS for the Canadian Transportation Act Review Secretariat.

Cryderman, K. & Jang, B. (2015, December 11). The Coal Bust, *Globe and Mail*.

CTAR (Canada Transportation Act Review). (2015a). *Pathways: Connecting Canada's Transportation System to the World – Volume 1*. Ottawa (ON): Government of Canada.

CTAR (Canada Transportation Act Review). (2015b). *Pathways: Connecting Canada's Transportation System to the World – Volume 2*. Ottawa (ON): Government of Canada.

Daschuk, J. W. (2013). *Clearing the Plains: Disease, Politics of Starvation, and the Loss of Aboriginal Life* (Vol. 65). Regina (SK): University of Regina Press.

Dawson, J., Johnston, M. E., & Stewart, E. J. (2014). Governance of Arctic expedition cruise ships in a time of rapid environmental and economic change. *Ocean & Coastal Management, 89*, 88-99.

Derksen, C., Smith, S. L., Sharp, M., Brown, L., Howell, S., Copland, L.,... Walker, A. (2012). Variability and change in the Canadian cryosphere. *Climatic Change, 115*(1), 59-88.

Deur, D. & Turner, N. J. (2005). *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*. Seattle (WA): University of Washington Press.

DFO (Fisheries and Oceans Canada). (2008). *Science at Fisheries and Oceans Canada: A Framework for the Future*. Ottawa (ON): DFO.

DFO (Department of Fisheries and Oceans Canada). (2009). *Economic Impact of Marine Related Activities in Canada*. Ottawa (ON): DFO.

Diamond, J. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. New York (NY): W. W. Norton & Company

DNV GL. (2014). *The Future of Shipping*. Høvik, Norway: DNV GL.

Dooms, M., Haezendonck, E., & Verbeke, A. (2015). Towards a meta-analysis and toolkit for port-related socio-economic impacts: A review of socio-economic impact studies conducted for seaports. *Maritime Policy & Management, 42*(5), 459-480.

Easterbrook, W. T. & Watkins, M. (1984). *Approaches to Canadian Economic History: A Selection of Essays*. Montréal (QC): McGill-Queen's Press-MQUP.

Eccles, W. & Foster, J. (2015). *Fur Trade*. Toronto (ON): The Canadian Encyclopedia.

Edgell, S., Gottfried, H., & Granter, E. (Eds.). (2015). *The SAGE Handbook of the Sociology of Work and Employment*. London, United Kingdom: SAGE Publications Ltd.

Environment Canada. (2016). Criteria Air Contaminants and Related Pollutants. Retrieved August, 2016, from https://www.ec.gc.ca/air/default.asp?lang=En&n=7C43740B-1.

EPA (United States Environmental Protection Agency). (2010). *Designation of North American Emission Control Area to Reduce Emissions from Ships*. Ann Arbor (MI): EPA.

ESPO (European Sea Ports Organization). (2013). *ESPO Port Performance Dashboard*. Brussels, Belgium: ESPO.

Eyring, V., Köhler, H. W., van Aardenne, J., & Lauer, A. (2005). Emissions from international shipping: 1. The last 50 years. *Journal of Geophysical Research: Atmospheres, 110*(D17).

Fisher, R. (1992). *Contact and Conflict: Indian-European Relations in British Columbia, 1774-1890*. Vancouver (BC): UBC Press.

Fortescue. (2011). *Port Facility - Dust Environmental Management Plan*. East Perth, Australia: Fortescue.

Frankel, J. A. & Rose, A. K. (2002). Is Trade Good or Bad for the Environment? Sorting Out the Causality. *National Bureau of Economic Research Working Paper Series, No. 9201*.

Franklin, A. (2002). Consuming Design: Consuming Retro. In S. Miles, A. Anderson & K. Meethan (Eds.), *The Changing Consumer: Markets and Meaning*. New York (NY): Routledge.

GAO (U.S. Government Accountability Office). (2002). *Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem*. Washington (DC): GAO.

Gintis, H., Bowles, S., Boyd, R., & Fehr, E. (Eds.). (2005). *The Moral Sentiments and Material Interests: The Foundations of Cooperation in Economic Life*. Cambridge (MA): The MIT Press.

Gitga'at Nation. (2013). *Final Argument of the Gitga'at Nation: Enbridge Northern Gateway Project*. Hartley Bay (BC): Gitga'at Nation.

Glave, T., Joerss, M., & Saxon, S. (2014). *The Hidden Opportunity in Container Shipping*. Copenhagen, Denmark: McKinsey & Company

Global Affairs Canada. (2017). Statement on Canada's Arctic Foreign Policy: Exercising Sovereignty and Promoting Canada's Northern Strategy Abroad. Retrieved January 2017, from http://www.international.gc.ca/arctic-arctique/arctic_policy-canada-politique_arctique.aspx?lang=eng.

Gopinath, G., Helpman, E., & Rogoff, K. (Eds.). (2014). *Handbook of International Economics (Vol. 4)*. Amsterdam, Netherlands: Elsevier.

Gousse, S. & Foster, J. (2015). *Voyageur*. Toronto (ON): The Canadian Encyclopedia.

Government of Canada. (1985). *Task Force on Deep-Sea Shipping: Report to the Minister of Transport*. Ottawa (ON): Government of Canada.

Government of Canada. (1996). *Canada Transportation Act*. Ottawa (ON): Government of Canada.

Government of Canada. (2013). *Combating Terrorism Act, 2013*. Ottawa (ON): Government of Canada.

Government of Canada. (2017). Exercising Our Arctic Sovereignty. Retrieved January 2017, from http://www.northernstrategy.gc.ca/sov/index-eng.asp.

Government of Quebec. (2015). *The Maritime Strategy by the Year 2030*. Québec (QC): Government of Quebec.

Green Marine. (2015). *Self-Evaluation Guide - Environmental Program - Ports & Seaways Corporations 2015*. Québec City (QC): Green Marine.

Gros, D. & Alcidi, C. (2014). *The Global Economy in 2030: Trends and Strategies for Europe*. Brussels, Belgium: Centre for European Policy Studies.

Guo, Y., Berrang-Ford, L., Ford, J., Lardeau, M.-P., Edge, V., Patterson, K.,... Harper, S. (2015). Seasonal prevalence and determinants of food insecurity in Iqaluit, Nunavut. *International Journal of Circumpolar Health, 74*.

Guy, E. (2006). Evaluating the viability of commercial shipping in the Northwest Passage. *Journal of Ocean Technology, 1*(1), 9-18.

Guy, E. & Alix, Y. (2007). A successful upriver port? Container shipping in Montreal. *Journal of Transport Geography, 15*(1), 46-55.

Halifax Port Authority. (2015). *Economic Impact Study*. Halifax (NS): Halifax Port Authority.

Harari, Y. N. (2014). *Sapiens: A Brief History of Humankind*. Toronto (ON): McClelland & Stewart.

Harari, Y. N. (2016). *Homo Deus: A Brief History of Tomorrow*. Toronto (ON): Signal Books.

Heaver, T. (2015). *Shipping Industry*. Toronto (ON): The Canadian Encyclopedia.

Hodgson, J. R. F., Russell, W. D., & Megannety, M. (2013). *Exploring Plausible Futures for Marine Transportation in the Canadian Arctic: A Scenarios' Based Approach*. Ottawa (ON): Transport Canada.

Hodson, R. & Sullivan, T. A. (2002). *The Social Organization of Work (3rd edition)*. New York (NY): Wadsworth.

Holeck, K. T., Mills, E. L., MacIsaac, H. J., Dochoda, M. R., Colautti, R. I., & Ricciardi, A. (2004). Bridging troubled waters: Biological invasions, transoceanic shipping, and the Laurentian Great Lakes. *BioScience, 54*(10), 919-929.

Howell, S., Derksen, C., Pizzolato, L., & Brady, M. (2015). Multiyear ice replenishment in the Canadian Arctic Archipelago: 1997–2013. *Journal of Geophysical Research: Oceans, 120*(3), 1623-1637.

Hummels, D. (2001). *Towards a Geography of Trade Costs*. West Lafayette (IN): Purdue University.

Hummels, D., Ishii, J., & Kei-Mu, Y. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics, 54*, 75-96.

IHS Energy. (2014). *Crude by Rail: The new Logistics of Tight Oil and Oil Sands Growth*. Calgary (AB): IHS Energy.

IMO (International Maritime Organization). (2015). *Third IMO GHG Study 2014*. London, United Kingdom: IMO.

Industry Canada. (2013). *Canada's Changing Retail Market*. Ottawa (ON): Industry Canada,.

Innis, H. A. (1930). *The Fur Trade in Canada: An Introduction to Canadian Economic History*. Toronto (ON): University of Toronto Press.

Innis, H. A. (1999). *The Fur Trade in Canada: An Introduction to Canadian Economic History*. Toronto (ON): University of Toronto Press.

InterVISTAS. (2015). *Port of Prince Rupert Economic Impact Study*. Ottawa (ON): Prepared for Prince Rupert Port Authority.

Jacks, D. S. & Pendakur, K. (2010). Global trade and the maritime transport revolution. *The Review of Economics and Statistics 92*(4), 745-755.

Jackson, M. (2008). *Social and Economic Networks*. Princeton (NJ): Princeton University Press.

Jeffries, M. O., Overland, J. E., & Perovich, D. K. (2013). The Arctic shifts to a new normal. *Physics Today, 66*(10), 35-40.

Johnson, R. C. & Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics, 86*, 224-236.

Kaku, M. (2011). *Physics of the Future*. Toronto (ON): Random House.

Khon, V. C., Mokhov, I. I., Latif, M., Semenov, V. A., & Park, W. (2009). Perspectives of Northern Sea Route and Northwest Passage in the twenty-first century. *Climatic Change, 100*(3), 757-768.

KPMG. (2014). *Profile of the Transportation and Logistics Sector in Greater Montréal*. Montréal (QC): KPMG.

Krugman, P., Obstfeld, M., & Melitz, M. (2015). *International Economics: Theory and Policy 10th Edition*. New York (NY): Pearson.

Krugman, P. R. (1981). Intraindustry specialization and the gains from trade. *Journal of Political Economy, 89*(5), 959-973.

Kubat, I., Collins, A., & Timco, G. (2007). *Year-Round Shipping in the Canadian Arctic: Ice Conditions and Regulatory Requirements*. Paper presented at Recent development of offshore engineering in cold regions: POAC'07 Dalian, China, June 27-30, 2007: proceedings: 19th International Conference on Port and Ocean Engineering Under Arctic Conditions.

Lasserre, F. & Têtu, P.-L. (2015). The cruise tourism industry in the Canadian Arctic: Analysis of activities and perceptions of cruise ship operators. *Polar Record, 51*(1), 24-38.

LECG Corporation. (2004). *Marine Industry Benefits Study: Economic Impact of the Canadian Marine Transportation*. Toronto (ON): LECG Corporation.

Legget, R. (2015). *Canals and Inlands Waterways*. Toronto (ON): The Canadian Encyclopedia.

Levinson, M. (2008). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton (NJ): Princeton University Press.

Lindner, J. & McEwan, B. (2012). *Experiences Conducting Port Emissions Inventories in Canada*. Paper presented at 2012 International Emission Inventory Conference Emission Inventories: Meeting the Challenges Posed by Emerging Global, National, Regional and Local Air Quality Issues, Tampa (FL).

Lovell, S. J., Stone, S. F., & Fernandez, L. (2006). The Economic impacts of aquatic invasive species: A review of the literature. *Agricultural and Resource Economics Review, 35*(1), 195-208.

Mackintosh, W. A. (1923). Economic factors in Canadian history. *Canadian Historical Review, 4*(1), 12-25.

MaPP (Marine Plan Partnership for the North Pacific Coast). (2016). About MaPP. Retrieved August, 2016, from http://mappocean.org/about-mapp/.

Marsh, J. (2016). *Bluenose*. Toronto (ON): The Canadian Encyclopedia.

Martin Associates. (2011). *The Economic Impacts of the Great Lakes-St. Lawrence Seaway System*. Lancaster (PA): Martin Associates.

McIntosh, C. R. (2013). The fuel use and air emission consequences of shipping Great Lakes coal through the Soo Locks. *Transportation Research Part D: Transport and Environment, 18*, 117-121.

McKenna, N. (2016). The Role of Marine Shipping in Canadian Tire's Supply Chain. Toronto (ON): Canadian Tire Corporation.

Melitz, M. & Trefler, D. (2012). Gains from trade when firms matter. *Journal of Economic Perspectives, 26*(2), 91-118.

Merk, O. (2014). *Shipping Emissions in Ports*. Paris, France: OECD.

MGI (McKinsey Global Institute). (2016). *Digital Globalization: The New Era of Global Flows*. New York (NY): McKinsey and Company.

Miller, J. R. (2009). *Compact, Contract, Covenant: Aboriginal Treaty-Making in Canada*. Toronto (ON): University of Toronto Press.

Montreal Port Authority. (2014a). Environment. Retrieved April, 2016, from http://www.port-montreal.com/en/environment-about.html.

Montreal Port Authority. (2014b). *The Port at the Heart of its Community*. Montréal (QC): Montreal Port Authority.

Montreal Port Authority. (2014c). Social Responsibility. Retrieved April, 2016, from http://www.port-montreal.com/en/social-responsability-communauty.html.

Montreal Port Authority. (2015). *The Port of Montreal in Brief*. Montréal (QC): Montreal Port Authority.

Moore, J. H. (Ed.). (1993). *The Political Economy of North American Indians*. Norman (OK): The University of Oklahoma Press.

Morton, D. (2006). *A Short History of Canada: Sixth Edition*. Toronto (ON): McClelland & Stewart.

North Atlantic Refining LP. (2006). Our Newfoundland Oil Refinery. Retrieved February, 2016, from http://www.narefining.ca/about.asp.

NRCan (Natural Resources Canada). (2012). Coal - Other Information. Retrieved November, 2016, from http://www.nrcan.gc.ca/mining-materials/markets/commodity-reviews/2012/14377.

NRCan (Natural Resources Canada). (2016). *Minerals and Metals Fact Book - 2016*. Ottawa (ON): NRCan.

Nunavut Energy Secretariat. (2014). Nunavut's Energy System. Retrieved January, 2016, from http://www.nunavutenergy.ca/Nunavuts_Energy_System.

Nunavut Housing Corporation. (2012). *Igluliuqatigiilauqta: Let's Build a Home Together. Framework for the GN Long-Term Comprehensive Housing and Homelessness Strategy*. Iqaluit (NU): Nunavut Housing Corporation.

OECD (Organisation for Economic Co-operation and Development). (2014). *The Competitiveness of Global Port-Cities: Synthesis Report*. Paris, France: OECD.

Offer, A. (2012). Consumption and Well-Being. In F. Trentmann (Ed.), *The Oxford Handbook of the History of Consumption* Oxford, United Kingdom: Oxford University Press.

Ostrom, E. (2005). *Understanding Institutional Diversity*. Princeton (NJ): Princeton University Press.

Pederson, M. W., Anthony, R., & Scheweger, C. (2016). Postglacial viability and colonialization in North America's ice-free corridor. *Nature, 537*(45-49).

Pizzolato, L., Howell, S. E. L., Derksen, C., Dawson, J., & Copland, L. (2014). Changing sea ice conditions and marine transportation activity in Canadian Arctic waters between 1990 and 2012. *Climatic Change, 123*(2), 161-173.

PNCIMA (Pacific North Coast Integreted Management Area). (2016). PNCIMA Initiative. Retrieved October 2016, from http://www.pncima.org/.

Port of Vancouver. (2015). *Enhancing Cetacean Habitat and Observation (ECHO) Program 2015 Annual Report* Vancouver (BC): Port of Vancouver.

Port of Vancouver. (2016). Marine Mammals. Retrieved July, 2016, from http://www.portvancouver.com/environment/water-land-wildlife/marine-mammals/.

Poten & Partners. (2013). *Weekly Tanker Opinion*. New York (NY): Poten & Partners.

Prowse, T. D., Furgal, C., Chouinard, R., Melling, H., Milburn, D., & Smith, S. L. (2009). Implications of climate change for economic development in northern Canada: Energy, resource, and transportation sectors. *Ambio, 38*(5), 272-281.

Public Safety Canada. (2015). *Marine Ports and Organized Crime*. Ottawa (ON): Public Safety Canada.

PwC (PricewaterhousCoopers). (2012). *Economic Impact Analysis of the Coal Mining Industry in Canada*. Ottawa (ON): Produced by PwC for the Coal Association of Canada.

PwC (PricewaterhouseCoopers). (2015). *The World in 2050: Will the Shift in Global Economic Power Continue*. London, United Kingdom: PwC.

Quorum Corporation. (2014). *2013-2014 Annual Crop Year Report, Grain Handling and Transportation System*. Edmonton (AB): Quorum Corporation.

Research and Traffic Group. (2013). *Environmental and Social Impacts of the Great Lakes-St. Lawrence Seaway System*. Glenburnie (ON): Research and Traffic Group.

Ricardo, D. (1817). On the Principles of Political Economy and Taxation. Retrieved September 2016, from https://books.google.ca/books?id=cUBKAAAAYAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false.

Rodrik, D. (1997). *Has Globalization Gone Too Far?* Washington (DC): Institute for International Economics.

Rothman, R. A. (1998). *Working: Sociological Perspectives*. Upper Saddle River (NJ): Prentice Hall.

Sharma, D. C. (2006). Ports in a storm. *Environmental Health Perspectives, 114*(4), A222-A231.

Sinclair, P. (1999). Industrialization and rural development: Contrasting labour markets and perceptions of the future on the Bonavista Peninsula and the Isthmus of Avalon, Newfoundland. *Newfoundland Studies, 15*(1), 56-78.

Somanathan, S., Flynn, P. C., & Szymanski, J. K. (2007). Feasibility of a sea route through the Canadian Arctic. *Maritime Economics & Logistics, 9*(4), 324-334.

Statistics Canada. (2012). *Shipping in Canada 2011*. Ottawa (ON): Statistics Canada.

Statistics Canada. (2015). *Statistics Canada's Canadian International Merchandise Trade Database*. Ottawa (ON): Statistics Canada.

Statistics Canada. (2016a). *GDP by Industry, CANSIM Table 379-0031*. Ottawa (ON): Statistics Canada.

Statistics Canada. (2016b). *Employment by Industry, CANSIM Table 282-0008*. Ottawa (ON): Statistics Canada.

Statistics Canada. (2017). *GDP by Industry, CANSIM Table 379-0031*. Ottawa (ON): Statistics Canada.

Stephenson, S. R., Smith, L. C., & Agnew, J. A. (2011). Divergent long-term trajectories of human access to the Arctic. *Nature Climate Change, 1*(3), 156-160.

Stiglitz, J. E. (2002). *Globalization and its Discontents*. New York (NY): W. W. Norton & Company.

Sys, C. (2009). Is the container liner shipping industry an oligopoly? *Transport policy, 16*(5), 259-270.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., & de Vries, G. J. (2015). An illustrated user guide to the World Input–Output Database: The case of global automotive production. *Review of International Economics, 23*, 575-605.

Transport Canada. (2015a). *Transportation in Canada 2014: Statistical Addendum*. Ottawa (ON): Government of Canada.

Transport Canada. (2015b). *Transportation in Canada 2014*. Ottawa (ON): Government of Canada.

Transportation Research Board. (2012). *Multimodal Freight Transportation Within the Great Lakes-Saint Lawrence Basin*. Washington (D.C.): National Academy of Science.

Transportation Safety Board of Canada. (2015). Statistical Summary – Marine Occurrences 2015. Retrieved January 2017, from http://www.bst-tsb.gc.ca/eng/stats/marine/2015/ssem-ssmo-2015-tbls.asp.

UNCTAD (United Nations Conference on Trade and Development). (2015). *Review of Maritime Transport*. New York (NY): United Nations.

Vallas, S. (2011). Sociology of Work and Employment. In *Oxford Bibliographies in Sociology*. Oxford, United Kingdom: Oxford University Press.

Van Wychen, W., Burgess, D. O., Gray, L., Copland, L., Sharp, M., Dowdeswell, J. A., & Benham, T. J. (2014). Glacier velocities and dynamic ice discharge from the Queen Elizabeth Islands, Nunavut, Canada. *Geophysical Research Letters, 41*(2), 484-490.

Walker, T. R. (2016). Green Marine: An environmental program to establish sustainability in marine transportation. *Marine Pollution Bulletin, 105*(1), 199-207.

Watkins, M. H. (1963). A staple theory of economic growth. *The Canadian Journal of Economics and Political Science, 29*(2), 141-158.

Weber, A. (2011). Water Transportation and the Maritime Industries. In International Labour Organization (Ed.), *Encyclopedia of Occupational Health & Safety*. Geneva, Switzerland: International Labour Organization.

World Bank. (2015). Exports of Goods and Services (% of GDP). Retrieved June 2016, from http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS.

World Bank. (2016). World Integrated Trade Solution (WITS) Product Concordance. Retrieved June 2016, from http://wits.worldbank.org/product_concordance.html.

WTO (World Trade Organization). (2016). *World Trade Statistical Review*. Geneva, Switzerland: WTO.

WWF (World Wildlife Fund). (2013). *A Primer on Underwater Sound and Noise: Backgrounder for WWF's 2013 Workshop on Finding Management Solutions for Underwater Noise in Canada's Pacific*. Toronto (ON): WWF.

Wynne, G. (2015). *Timber Trade History*. Toronto (ON): The Canadian Encyclopedia.

Zilberstein, A. (2016). *A Temperate Empire: Making Climate Change in Early America*. New York (NY): Oxford University Press.

Appendices

Appendix A Data Used in the Quantitative Trade Model

This appendix presents the details of the data used in the quantitative general equilibrium trade model that was commissioned by the Panel and used to measure the effects of international marine trade on the Canadian economy. The model extends the model in Caliendo and Parro (2015), a Ricardian trade model with industry heterogeneity, industry linkages, and trade in intermediate goods, by incorporating different modes of transportation. This approach is a novel contribution to international trade literature, which completely abstracts away from modelling choice of transportation mode. Specifically, it allows firms to search for the lowest-cost supplier across countries and every possible mode of transportation. The model enables quantification of how a change in the cost of a particular mode of transportation affects a range of economic outcomes including production, trade, wages, prices, and ultimately GDP.

The model employs two main data sources. First, WIOD is an annual time-series of world I-O tables and factor requirements covering the period from 1995 to 2011 for 40 countries (Timmer *et al.*, 2015).[43] To account for general equilibrium effects coming from trade between third countries, trade flows between countries other than Canada are obtained from these I-O tables. Since total purchases made by a given country from any other country, including domestic sales, are known, this provides bilateral trade flows. Since WIOD does not contain information on transportation modes, trade flows between third countries are not differentiated by mode of transportation in the model.

Second, trade flows between Canada and other countries by commodity and transportation mode are from Statistics Canada's Canadian International Merchandise Trade Database (Statistics Canada, 2015). Commodities are classified according to the 6-digit HS, and were converted to 3-digit ISIC industry classification using concordance tables (World Bank, 2016). Trade flows are

43 The "rest of the world" is constructed by linking international trade statistics for 35 industries (Timmer *et al.*, 2015).

also classified into five transportation modes: water, air, rail, road, and other. Industry exports from Canada to other countries by transportation mode were constructed by aggregating exports by each Canadian province of origin, and by defining the country of destination as the importing country. Similarly, industry imports to Canada from other countries were constructed by aggregating imports by each Canadian province of clearance, and by defining the country of origin as the exporting country. Exports and imports by transportation mode allow for the construct of the bilateral trade shares.

The intersection between industry trade flows for other countries, from WIOD, and the industry trade flows for Canada by transport mode, from Statistics Canada, covers 34 industries (Table A.1) and 41 countries (Table A.2). The model is estimated using 2011 data, which is the latest year with all the trade and production data available from both data sets. Trade cost elasticities by industry are presented in Table A.3.

Table A.1

Industries in the Model, Tradable and Non-Tradable

Tradable Industry	Label
Agriculture, Hunting, Forestry, and Fishing	Agriculture
Mining and Quarrying	Mining
Food, Beverages, and Tobacco	Food, Bever., Tobb
Textiles and Textile Products	Textiles
Leather, Leather, and Footwear	Leather
Wood and Products of Wood and Cork	Wood
Pulp, Paper, Paper , Printing, and Publishing	Paper
Coke, Refined Petroleum, and Nuclear Fuel	Petroleum
Chemicals and Chemical Products	Chemicals
Rubber and Plastics	Plastics
Other Non-Metallic Mineral	Non-Metallic Min.
Basic Metals and Fabricated Metal	Metals
Machinery, Nec	Machinery
Electrical and Optical Equipment	Electrical Equip.
Transport Equipment	Transport Equip.
Manufacturing, Nec	Other Machinery
Non-Tradable Industry	**Label**
Electricity, Gas, and Water Supply	Electricity
Construction	Construction
Sale, Maint.Repair of MV and MTRCL, Retail Sale of Fuel	Sale Maint. Mtr. Veh.
Wholesale Trade and Comm. Trade, Exc. MV, and MTRCL	Wholesale Trade
Retail Trade, Exc. MV and MTRCL, Repair of HH Goods	Retail Trade
Hotels and Restaurants	Hotels and Restaurants
Inland Transport	Inland Transport Serv.
Water Transport	Water Transport Serv.
Air Transport	Air Transport Serv.
Other Supp. and Aux. Transp. Act., Act. of Tr. Agencies	Other Transport Serv.
Post and Telecommunications	Post and Telecom.
Financial Intermediation	Finance
Real Estate Activities	Real Estate
Renting of M&Eq and Other Business Activities	Other Business
Public Admin and Defence	Public Adm.
Education	Education
Health and Social Work	Health
Other Community, Social and Personal Services	Other Services

Data Source: Statistics Canada, 2015

Table A.2

Countries in the Model

Australia	Finland	Korea	Russia
Austria	France	Latvia	Slovakia
Belgium	Germany	Lithuania	Slovenia
Bulgaria	Greece	Luxembourg	Spain
Brazil	Hungary	Mexico	Sweden
Canada	Indonesia	Malta	Turkey
China	India	Netherlands	Taiwan
Cyprus	Ireland	Poland	United Kingdom
Czech Republic	Italy	Portugal	United States
Denmark	Japan	Romania	Rest of the World
Estonia			

Data Source: Statistics Canada, 2015

Table A.3

Trade Cost Elasticities, Tradable Industries

Tradable Industry	Elasticity	Tradable Industry	Elasticity
Agriculture	8.11	Chemicals	4.75
Mining	15.72	Plastics	1.66
Food, Bever., Tobb	2.55	Non-Metallic Min.	2.76
Textiles	5.56	Metals	6.78
Leather	5.66	Machinery	12.79
Wood	10.83	Electrical Equip.	10.60
Paper	9.07	Transport Equip.	1.01
Petroleum	51.08	Other Machinery	5.00

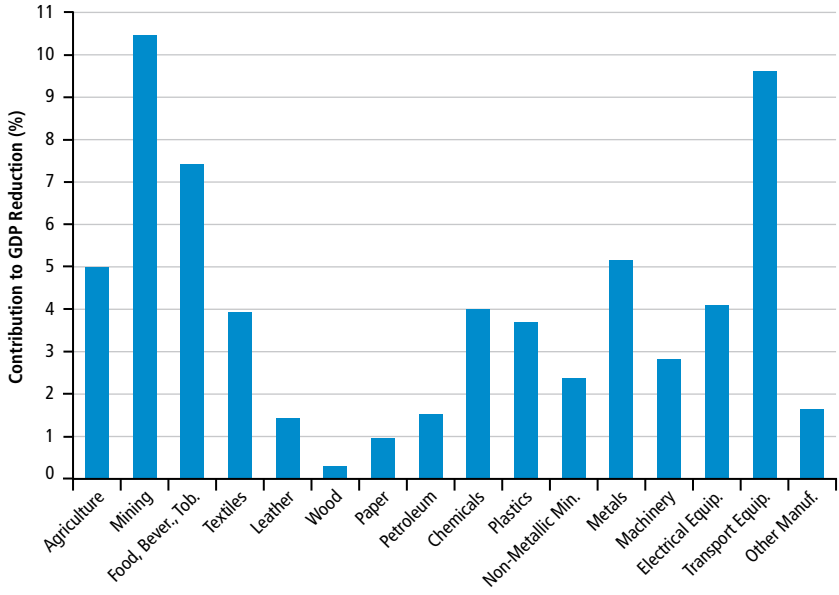

Figure A.1

Industry Contribution to the Overall Reduction in Canadian GDP, Tradable Industries

The figure presents the percentage reduction in the GDP of each Canadian tradable industry that would result from hypothetically shutting down commercial marine shipping.

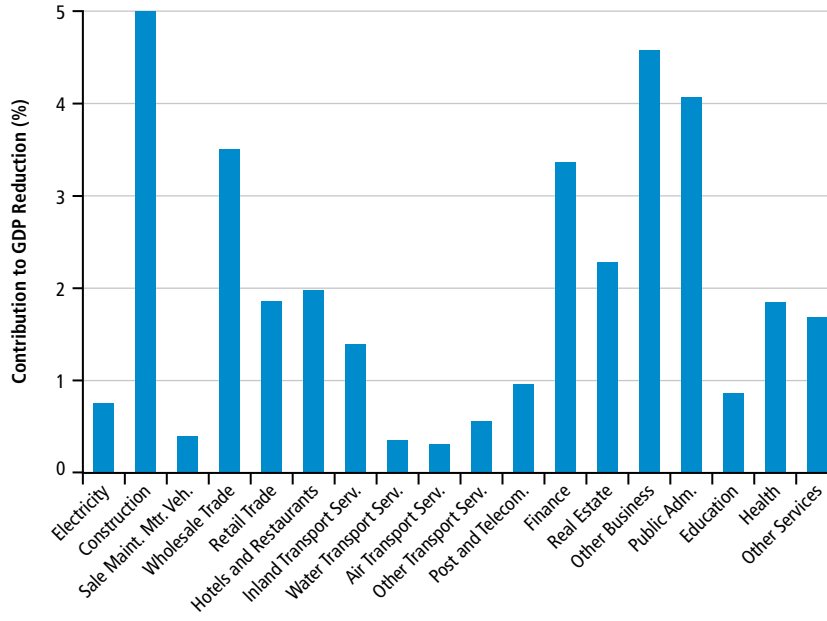

Figure A.2

Industry Contribution to the Overall Reduction in Canadian GDP, Non-tradable Industries

The figure presents the percentage reduction in the GDP of each Canadian non-tradable industry that would result from hypothetically shutting down commercial marine shipping.

Appendix B Data on Marine Trade

This appendix provides data on the top marine export and import commodities by volume and value (Tables B.1 to B.4). It also includes data on crude oil exports and imports, specifically in Tables B.5 and B.6.

Table B.1

Top 10 Marine Export Commodities by Volume, 2011 and 2002

	2011		2002		2002-2011
	Volume (Mt)	Share (%)	Volume (Mt)	Share (%)	Growth (CAGR) (%)
Coal	43.3	19.1	24.6	14.1	6.5
Iron ores and concentrates	36.4	16.0	25.2	14.5	4.2
Crude oil	21.4	9.4	15.3	8.8	4.0
Wheat	15.6	6.9	10.4	6.0	4.6
Fuel oils	10.9	4.8	6.7	3.9	5.6
Potash	8.0	3.5	3.9	2.2	8.3
Canola	6.7	3.0	1.5	0.9	18.3
Gasoline and aviation turbine fuel	6.0	2.6	9.7	5.6	-5.2
Wood pulp	6.0	2.6	5.8	3.3	1.9
Lumber	5.7	2.5	3.1	1.8	7.0
Other	67.2	29.6	54.9	24.2	2.3
Total	**227.3**		**174.3**		**3.0**

Data Source: Statistics Canada, 2012

Table B.2

Top 15 Marine Export Commodities by Total Value, 2006–2015

Commodity Type	Total Value ($B)	Share (%)
Mineral fuels, oils and products of distillation; bituminous subs; mineral waxes	254.4	28.8
Ores, slag and ash	69.1	7.8
Cereals	58.3	6.6
Oil seed & oleaginous fruits; grains, seeds & fruit; ind & medicinal plants; straw	51.9	5.9
Nickel and articles thereof	44.9	5.1
Pulp of wood/of other fibrous cellulosic mat; recovered waste	41.3	4.7
Machinery, boilers, mechanical appliances, engines, pts	34.8	3.9
Wood and articles of wood; wood charcoal	32.2	3.6
Fertilizers	24.1	2.7
Edible vegetables and certain roots and tubers	21.0	2.4
Meat and edible meat offal	20.6	2.3
Paper and paperboard; articles of paper pulp, of paper or of paperboard	19.0	2.1
Aluminum and articles thereof	18.4	2.1
Organic chemicals	14.5	1.6
Iron and steel	13.3	1.5

Data Source: Statistics Canada, 2015

Table B.3

Top 10 Marine Import Commodities by Volume, 2011 and 2002

	2011		2002		2002-2011
	Volume (Mt)	Share (%)	Volume (Mt)	Share (%)	Growth (CAGR)
Crude petroleum	36.1	31.6	28.4	24.9	2.7
Coal	9.8	8.6	21.7	19.0	-8.5
Iron ores and concentrates	9.3	8.1	6.9	6.0	3.4
Gasoline and aviation turbine fuel	8.4	7.3	4.4	3.9	7.3
Other manufactured goods	5.0	4.4	3.8	3.3	3.2
Alumina	4.5	3.9	4.3	3.8	0.4
Aluminum ores (bauxite)	3.6	3.2	3.1	2.7	1.9
Fuel oils	2.5	2.2	1.9	1.7	3.2
Other refined petroleum and coal products	2.4	2.1	0.9	0.8	12.1
Limestone	2.2	1.9	2.7	2.4	-2.3
Other	30.4	26.6	30.3	26.5	0.0
Total	**114.3**		**108.5**	**0.5**	**0.6**

Data Source: Statistics Canada, 2012

Table B.4

Top 15 Marine Import Commodities by Total Value, 2006–2015

Commodity Type	Total Value ($B)	Share (%)
Mineral fuels, oils and products of distillation; bituminous subs; mineral waxes	272.4	28.0
Vehicles o/t railw/tramw roll-stock, pts & accessories	102.0	10.5
Machinery, boilers, mechanical appliances, engines, pts	42.7	4.4
Nuclear reactors, boilers, machinery and mechanical appliances; Parts thereof	38.2	3.9
Articles of iron or steel	30.7	3.1
Furniture; bedding, mattress, matt support, cushion, etc.	28.4	2.9
Electrical mchy, equip & parts; Sound rec & repro, tv image & sound rec & repro, p&a	25.2	2.6
Electrical mchy equip parts thereof; sound recorder, etc.	23.4	2.4
Ores, slag and ash	23.0	2.4
Beverages, spirits and vinegar	21.0	2.1
Iron and steel	20.0	2.0
Plastics and articles thereof	18.8	1.9
Pharmaceutical products	17.7	1.8
Rubber and articles thereof	17.7	1.8
Articles of apparel and clothing accessories, knitted or crocheted	17.6	1.8

Data Source: Statistics Canada, 2015

Table B.5

Crude Oil Exports and Imports, 2011

Destination	Exports (Tonnes)	Imports (Tonnes)
Asia	470,400	0
Africa	0	20,227,700
Europe	1,206,800	6,714,800
Middle East	0	6,971,100
South America	209,000	1,961,900
US – Atlantic and Gulf	17,805,900	201,800
US – Great Lakes	0	8,900
US – Pacific	1,686,000	0
Total	**21,378,100**	**36,086,200**

Data Source: Statistics Canada, 2012

Table B.6

Crude Oil Shipping by Port, 2011

Port	Domestic Loaded (Tonnes)	Domestic Unloaded (Tonnes)	Exports (Tonnes)	Imports (Tonnes)
Vancouver	0	0	2,198,400	0
Montréal	0	0	49,700	64,800
Québec	0	0	0	9,873,500
Saint John	0	2,891,700	352,700	12,170,500
Port Hawkesbury	0	0	9,362,300	9,179,600
Come By Chance	2,150,100	10,203,900	8,132,000	3,246,300
Newfoundland Offshore	12,173,600	0	1,272,000	0
Other	0	800	11,800	1,096,500
Total	**14,323,700**	**13,096,400**	**21,378,900**	**36,086,200**

Data Source: Statistics Canada, 2012

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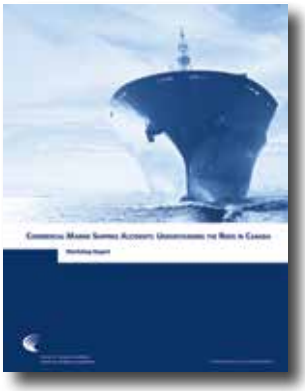
The assessment reports listed below are accessible through the CCA's website (**www.scienceadvice.ca**):



Commercial Marine Shipping Accidents: Understanding the Risks in Canada (2016)

Ocean Science in Canada: Meeting the Challenge, Seizing the Opportunity (2013)

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