Energy Prices and Business Decision-Making in Canada: Preparing for the Energy Future

The Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

ENERGY PRICES AND BUSINESS DECISION-MAKING IN CANADA: PREPARING FOR THE ENERGY FUTURE

The Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use

THE COUNCIL OF CANADIAN ACADEMIES
180 Elgin Street, Suite 1401, Ottawa, ON, Canada K2P 2K3

Notice: The project that is the subject of this report was undertaken with the approval of the Board of Governors of the Council of Canadian Academies. Board members are drawn from the Royal Society of Canada (RSC), the Canadian Academy of Engineering (CAE), and the Canadian Academy of Health Sciences (CAHS), as well as from the general public. The members of the expert panel responsible for the report were selected by the Council for their special competencies and with regard for appropriate balance.

This report was prepared for the Government of Canada in response to a request from the Minister of Industry. Any opinions, findings, or conclusions expressed in this publication are those of the authors, the Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use, and do not necessarily represent the views of their organizations of affiliation or employment.

Library and Archives Canada Cataloguing in Publication
Energy prices and business decision-making in Canada : preparing for the energy future / The Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use.

Issued also in French under title: Prix de l'énergie et prise de décision dans les entreprises au Canada.
Includes bibliographical references and index.
Issued in print and electronic formats.

ISBN 978-1-926558-93-6 (bound). ISBN 978-1-926558-94-3 (pdf)

1. Power resources–Prices–Canada. 2. Industries–Energy consumption–Canada. 3. Energy policy–Canada. I. Council of Canadian Academies. Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use, author

HD9502.C32E594 2014 333.790971 C2014-904477-1
C2014-904478-X

This report can be cited as: Council of Canadian Academies, 2014. *Energy Prices and Business Decision-Making in Canada: Preparing for the Energy Future.* Ottawa (ON): The Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use, Council of Canadian Academies.

Disclaimer: The internet data and information referenced in this report were correct, to the best of the Council's knowledge, at the time of publication. Due to the dynamic nature of the internet, resources that are free and publicly available may subsequently require a fee or restrict access, and the location of items may change as menus and webpages are reorganized.

Printed in Ottawa, Canada

Council of Canadian Academies
Conseil des académies canadiennes

Canada This assessment was made possible with the support of the Government of Canada.

The Council of Canadian Academies

Science Advice in the Public Interest

The Council of Canadian Academies is an independent, not-for-profit corporation that supports independent, science-based, expert assessments to inform public policy development in Canada. Led by a 12-member Board of Governors and advised by a 16-member Scientific Advisory Committee, the Council's work encompasses a broad definition of "science," incorporating the natural, social, and health sciences as well as engineering and the humanities. Council assessments are conducted by independent, multidisciplinary panels of experts from across Canada and abroad. Assessments strive to identify emerging issues, gaps in knowledge, Canadian strengths, and international trends and practices. Upon completion, assessments provide government decision-makers, academia, and stakeholders with high-quality information required to develop informed and innovative public policy.

All Council assessments undergo a formal report review and are published and made available to the public free of charge in English and French. Assessments can be referred to the Council by foundations, non-governmental organizations, the private sector, or any level of government. The Council is also supported by its three founding Member Academies:

The Royal Society of Canada (RSC) is the senior national body of distinguished Canadian scholars, artists, and scientists. The primary objective of the RSC is to promote learning and research in the arts and sciences. The RSC consists of nearly 2,000 Fellows — men and women who are selected by their peers for outstanding contributions to the natural and social sciences, the arts, and the humanities. The RSC exists to recognize academic excellence, to advise governments and organizations, and to promote Canadian culture.

The Canadian Academy of Engineering (CAE) is the national institution through which Canada's most distinguished and experienced engineers provide strategic advice on matters of critical importance to Canada. The Academy is an independent, self-governing, and non-profit organization established in 1987. Fellows of the Academy are nominated and elected by their peers in recognition of their distinguished achievements and career-long service to the engineering profession. Fellows of the Academy, who number approximately 600, are committed to ensuring that Canada's engineering expertise is applied to the benefit of all Canadians.

The Canadian Academy of Health Sciences (CAHS) recognizes individuals of great achievement in the academic health sciences in Canada. Founded in 2004, CAHS has approximately 400 Fellows and appoints new Fellows on an annual basis. The organization is managed by a voluntary Board of Directors and a Board Executive. The main function of CAHS is to provide timely, informed, and unbiased assessments of urgent issues affecting the health of Canadians. The Academy also monitors global health-related events to enhance Canada's state of readiness for the future, and provides a Canadian voice for health sciences internationally. CAHS provides a collective, authoritative, multidisciplinary voice on behalf of the health sciences community.

www.scienceadvice.ca
@scienceadvice

Expert Panel on the Canadian Industry's Competitiveness in Terms of Energy Use

Frederick W. Gorbet, O.C. (Chair), Expert Panel on the Canadian Industry's Competitiveness in Terms of Energy Use

Michelle Adams, Associate Professor, School for Resource and Environmental Studies, Dalhousie University (Halifax, NS)

Jean-Thomas Bernard, FRSC, Chair of Electricity Economics, Université Laval (Quebec, QC); Visiting Scholar, University of Ottawa (Ottawa, ON)

Paul Boothe, Professor and Director, Lawrence National Centre for Policy and Management, Ivey Business School, Western University (London, ON)

Ujjayant Chakravorty, Professor of Economics, Tufts University (Medford, MA)

Robert L. Evans, FCAE, Professor Emeritus of Mechanical Engineering, University of British Columbia (Vancouver, BC)

Oliver Inderwildi, Senior Policy Fellow, University of Oxford (Oxford, United Kingdom); Senior Manager and Global Leadership Fellow, Chemicals, Advanced Materials and Emerging Technologies, World Economic Forum (Geneva, Switzerland); and Visiting Professor, University of Turin (Turin, Italy)

David Lindsay, President and CEO, Forest Products Association of Canada (Ottawa, ON)

Wade Locke, Professor of Economics, Memorial University of Newfoundland (St. John's, NL)

John R. Muir, Former Director, Energy Policy and Government Affairs, GE Canada (Mississauga, ON)

Ken Norrie, Professor Emeritus of Economics, McMaster University (Hamilton, ON)

John Nyboer, Adjunct Professor, School of Resource and Environmental Management, Simon Fraser University (Burnaby, BC)

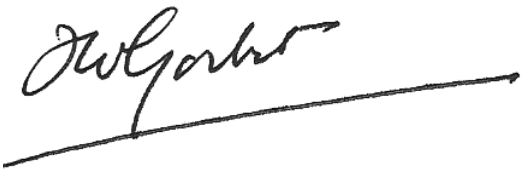
Denise Young, Professor of Economics, University of Alberta (Edmonton, AB)

Message from the Chair

Over the past several decades energy prices have figured prominently in business decision-making in Canada. This report provides a comprehensive overview of how well Canadian businesses have adapted to upward-trending and increasingly volatile energy prices, and explores ways in which businesses can enhance their resilience with respect to energy prices.

I am privileged to have been able to chair the Expert Panel charged with examining these issues, and I want to take this opportunity to thank the panelists. The breadth of background, experience, and expertise within the Panel made each of our interactions an excellent learning experience for all of us, and led to a strong report that went beyond existing theory and statistical evidence to develop valuable survey-based information. My fellow Panel members gave generously of their time and energy and I am grateful for their active and constructive participation.

I also want to thank the Council staff who supported the Panel and played a key role in developing the research that provided the evidence on which our conclusions are based.



Frederick W. Gorbet, O.C.
Chair, Expert Panel on Canadian Industry's Competitiveness in Terms of Energy Use

Acknowledgments

The Expert Panel would like to thank Joe St. Lawrence of Statistics Canada for providing advice with data, and Derek Jansen of EKOS Research Associates for designing the survey.

The Panel would also like to express its appreciation to the many participants in its survey of business leaders for the time they dedicated to responding to the Panel's survey.

Project Staff of the Council of Canadian Academies

Assessment Team:	Doug Wright, Program Director
	Eleanor Fast, Program Director
	Aled ab Iorwerth, Research Associate
	Joe Rowsell, Research Associate
	Rachel Savidge, Intern
	Naomi Shuman, Intern
	Kristen Cucan, Program Coordinator
	Andrea Dowdall, Program Coordinator
With assistance from:	Clare Walker, Editor
	Jean Pierre Toupin, Translation from English to French
	Accurate Design & Communication, Report Design

Report 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 Council.

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

Cathy Bennett, Chief Executive Officer, Bennett Group of Companies (St. John's, NL)

Jacynthe Côté, Chief Executive, Rio Tinto Alcan (Montréal, QC)

Paolo G. Dottori, Vice President, Energy, Environment & Technology, Tembec (Temiscaming, QC)

John Grace, O.C., FRSC, FCAE, Professor and Canada Research Chair, University of British Columbia (Vancouver, BC)

Douglas H. Horswill, Senior Vice President, Teck Resources Limited (Vancouver, BC)

Andrew Leach, Associate Professor, Alberta School of Business, University of Alberta (Edmonton, AB)

Pierre Sein Pyun, Vice President, Government Affairs, Bombardier Inc. (Ottawa, ON)

Daniel Savas, Visiting Professor, School of Public Policy, Simon Fraser University (Burnaby, BC)

Vicky Sharpe, President and CEO, Sustainable Development Technology Canada (Ottawa, ON)

Robert G. Skinner, Executive Fellow, The School of Public Policy and Advisor to VP Research, University of Calgary (Calgary, AB)

Randy G. Woelfel, Chief Executive Officer, NOVA Chemicals Corporation (Calgary, AB)

The report review procedure was monitored on behalf of the Council's Board of Governors and Scientific Advisory Committee by **Norbert R. Morgenstern, C.M., FRSC, FCAE,** Professor (Emeritus), Civil Engineering, University of Alberta. The role of the report review monitor is to ensure that the Panel gives full and fair consideration to the submissions of the report reviewers. The Board of Governors of the Council authorizes public release of an expert panel report only after the report review monitor confirms that the Council's report review requirements have been satisfied. The Council thanks Dr. Morgenstern for his diligent contribution as report review monitor.

Executive Summary

Energy prices rose during the late 1990s and into the new century as economic growth in large developing economies in Asia fostered growing demand. While this trend benefitted those that explored for or produced energy or could help users limit their exposure to prices, it also created challenges for Canadian firms that make intensive use of energy. The onset of the recession in 2008 brought the upward trend in energy prices to an end, but was marked by a spike in oil price volatility. In July 2008 crude oil skyrocketed to nearly US$150 a barrel; by December 2008 the price had plummeted to around US$30.

Current price projections from energy agencies and researchers suggest that global economic recovery will likely result in upward pressure on energy prices overall, and particularly for oil, over the coming years. A structural trend of rising, but volatile, energy prices present both opportunities and challenges for Canadian firms, and will continue to have significant effects on Canada as a whole.

CHARGE TO THE PANEL

To better understand the implications of this uncertain energy future for Canadian firms, in July 2012 the Minister of Industry, on behalf of Industry Canada, asked the Council of Canadian Academies (the Council) to respond to the following charge:

> *What are the opportunities and risks to Canada related to the potential for sustained higher energy prices?*
> - *Looking forward, what are the expected impacts of higher energy prices on Canadian businesses?*
> - *How do Canadian businesses compare to foreign competitors in terms of their ability to adapt to a) sustained higher energy prices? b) energy price volatility episodes?*
> - *Which industry sectors and communities are inherently a) most vulnerable to higher energy prices? b) best equipped to leverage higher energy prices as a competitive advantage?*
> - *How prepared are industry sectors and communities to capitalize on opportunities or mitigate risks that result from higher energy prices?*

In response, the Council appointed a multidisciplinary panel of Canadian and international experts (the Panel) from the academic, business, and public sectors. At the onset of the assessment, the Panel met with the Sponsor to discuss the charge and how best to scope its work to make it manageable.

CHANGING ENERGY MARKETS

Although energy prices have fallen back from their 2008 peak, energy prices are expected to rise as the global economy continues to recover. However, rather than increasing the prices of all types of energy goods, energy markets will be much more complex. Advances in extracting oil and gas from shale formations will restrain energy prices in North America. Whether for use as a source of energy or as a feedstock, the price of natural gas is now significantly lower than the (energy-equivalent) price of oil, and is expected to remain so for some time. Electricity prices are generally influenced by government policy in most provinces, and therefore may not closely track prices in traded energy sources. Taken together, the decoupling of prices for different sources of energy implies that understanding business decision-making in the energy context hinges on the dynamics of prices of different types of energy – not just of a single energy price.

The development of shale gas and tight oil is transforming energy markets, particularly in the United States. Increasing U.S. demand for energy has traditionally pushed global energy prices upwards. However, increased domestic production will lower the need of the United States to import oil and gas from all countries. As the principal export market for Canadian oil and gas, this impact will be particularly significant for Canadian energy exporters. Energy-intensive firms in the United States will also benefit from increased supply conditions, which may challenge their Canadian competitors.

A range of other factors will also have an impact on energy choices going forward. Over the long term, energy prices will be affected by technological advances in energy efficiency, alternative energy sources, and technological solutions developed in industries not linked traditionally with energy markets, such as computer manufacturing and software engineering. Furthermore, increased environmental and safety regulations, such as for shale gas and greenhouse gases, will affect energy markets. Although the consequences of these changes were outside the scope of the Panel's charge, these phenomena underscore the growing complexity of the energy world, where drivers and impacts of business decision-making reflect more than just energy prices. The resilience of Canadian firms will be tested as energy markets become more complex.

EXAMINING THE EVIDENCE

Exposure of Canadian Firms to Energy Prices

Consistent with the agreed interpretation of the charge, the Panel concentrated on the direct impact of energy prices on Canadian business decision-making. To determine what types of firms were exposed to energy prices and the kinds of strategies they could employ to minimize their effects, the Panel drew on the theoretical and empirical economics literature.

This literature shows that some types of firms are exposed to energy prices. First, firms in sectors that use energy or capital intensively in their production processes face strong incentives to respond to changes in energy prices. Their strategies may focus on reducing energy use by investing in energy-efficient machinery and equipment, adopting new business processes, switching fuel sources, or hedging with financial instruments. Second, firms that sell products that use energy intensively have incentives to improve the energy efficiency of their products when energy prices increase.

Based on its review of the literature and selected criteria, the Panel identified eight sectors that were exposed to energy prices: the energy-intensive resource-based, manufacturing, and transportation services sectors; the capital-intensive oil and gas, mining, electric power, and other sectors; and the transport equipment sector. These sectors, which were the focus of analysis for the report, account for slightly more than one-quarter of Canadian business sector output. They include some sectors that would benefit from higher energy prices, such as oil and gas and electric power.

Past Resilience of Canadian Firms to Energy Prices

An important aspect of business management is resilience: the capacity to bounce back from adverse events. To examine the past resilience of Canadian firms to changes in energy prices, the Panel examined the performance of selected sectors since 2000. The expectation was that higher energy prices would result in lower energy-output ratios. By this definition, most of the sectors identified as being exposed to energy prices had adjusted to past episodes of higher and more volatile oil prices. These adjustments lowered the quantity of energy used in proportion to output for most Canadian industries.

The data suggest that some industries had faced challenges since 2000, notably the chemical, transport equipment, and paper manufacturing industries. Chemical manufacturing had been challenged because it used natural gas rather than oil as a feedstock and the price of natural gas was much higher than the price of oil, leading to a competitive disadvantage. However, this picture is now

reversing as the relative price of natural gas declines in North America. Motor vehicle manufacturing — a constituent of the transport equipment sector — also struggled as gasoline prices rose. The paper manufacturing industry is energy intensive, but faced more fundamental technological challenges such as the digitization of media.

International Competitiveness of Canadian Business

To the extent that the data allowed, industry-by-industry comparisons demonstrated roughly similar energy intensities between the United States and Canada. Many Canadian sectors exposed to energy prices have managed to contain energy costs to a greater extent than their counterparts in the United States. This suggests that there would be limited competitiveness challenges, in terms of lost market share, across most sectors if global energy prices were to increase, although global demand would tend to shift away from energy-intensive products. In Canada, prices of energy are generally low compared with many other countries, suggesting that Canada probably uses energy more intensively. Further, a pathway to greater efficiency has been laid out in other countries that have higher energy prices. This suggests that the cost of further adjustment might be relatively low in Canada because Canadian firms would find it easier to replicate what has been done by firms in other countries. Limits on the availability of internationally comparable data precluded further analysis.

Some types of firms, notably those in transportation services, would see competitiveness impacts through higher costs as a result of higher energy prices. If these firms could pass on costs to their customers, their competitiveness would be protected, but this pass-through of costs into prices would propagate the impact of energy prices throughout the economy. A further option becoming increasingly realistic in transportation services is to switch to using natural gas or electricity.

Energy Use and Decision-Making of Canadian Firms

To supplement and enrich the evidence from the literature review, analysis of the statistics, and sectoral histories, the Panel commissioned a survey of more than 1,000 Canadian firms. Consistent with the Panel's mandate, the surveyed firms were chosen to reflect those sectors exposed to energy prices, and are therefore not representative of Canadian business as a whole. The survey covered the eight sectors the Panel identified as exposed, as well as two additional sectors (wholesale and retail trade) that were not as exposed to energy prices for comparison.

The survey confirmed that firms' exposure to changing energy prices is related to their sectors' energy and capital intensity. Two-thirds of the firms surveyed reported that energy costs were very important or extremely important to their competitiveness, with concern greatest among those industries that use oil-based products. However, firms in other sectors also expressed concern that they would suffer significant adverse effects from energy price increases.

The survey provided other valuable information about how firms view their exposure to energy prices and about the strategies they have used in the past and might use in the future to deal with periods of high and volatile energy prices. Key findings from the survey included the following:

- Controlling energy costs was very or extremely important to the competitiveness of 66% of firms.
- The impact of higher costs through direct purchase of energy has been felt by 72% of firms.
- In response to the volatility in oil prices in 2008, 42% of firms changed strategy.
- To manage energy costs, 59% of firms have invested in equipment over the past few years.

Preparedness of Canadian Firms for Future Energy Markets

Preparedness was a key concept for the Panel to assess the resilience of Canadian firms in adjusting to new circumstances. Although most firms cannot meaningfully change their exposure to energy prices in the short run, they can act to improve their resilience by being prepared for future changes in energy markets. There was, however, little evidence available to the Panel on the characteristics of firms that might be prepared for future change. Hence, based on its review of the management and economic research, the Panel developed indicators of preparedness consisting of the availability of:

- timely, accurate, and relevant information about the evolution of energy markets;
- benchmarking data; and
- personnel specialized in understanding the implications of energy developments for the firm.

Many Canadian firms are prepared in terms of these three indicators. Of surveyed firms, 22% employed a person who undertook financial or economic analysis of energy prices and 16% employed a person who undertook technical analysis related to energy use; 52% sought out detailed information on energy prices; and 18% had information allowing them to benchmark against their competitors. Overall, 63% met the criterion of at least one indicator of preparedness with the majority having access to information about energy markets. About 25% of respondents met the criteria of at least two indicators, but only 5% met all three.

It was difficult to compare the extent of preparedness of Canadian firms with competitors because data limitations made it impossible to examine whether the degree of adjustment was greater in other countries, or whether firms in other countries had access to such resources. The survey did make it clear that although a relatively small proportion of firms had access to relevant information and technically skilled people, access increased with the degree of exposure to energy prices. The data did not allow the Panel to draw any inferences about whether structural barriers or high costs limited the number of firms with access.

Analysis of the survey results suggested that there was a link between the indicators of preparedness and changing strategy in response to energy price changes. For example, in response to price shocks in 2008, 59% of firms with benchmarking information, but only 40% of those without, took action. Causality is unclear. Do firms intending to change strategy seek information and dedicated staff, or do firms with information and dedicated staff learn they should change strategy? However, what does seem clear is that being prepared would be an advantage if energy prices were to change. Overall, the survey data suggest that there is an opportunity for many Canadian firms to become better prepared, through better and timelier information and access to specialized personnel, to meet future challenges and thus capitalize on opportunities.

OPPORTUNITIES AND RISKS FOR THE CANADIAN BUSINESS SECTOR

The increased availability of shale gas and tight oil in North America will result in future patterns of energy prices that are unlike those of the past. Together with the impacts of new technologies and heightened awareness of environmental and safety impacts of developing, transporting, and using fossil fuels, this will result in new opportunities and risks for Canadian firms.

The Panel found that the expected trends in energy prices would provide opportunities for some sectors. Industries that use natural gas as a feedstock will have inherent opportunities to benefit as oil prices continue to increase relative to natural gas prices. This trend will enhance the competitiveness of the Canadian chemical manufacturing industry in particular. The oil and gas extraction industry will see the value of its products increase. Firms that provide goods and services to these industries, including for exploration, production, and transmission, will have opportunities particularly as current uncertainties about pipeline development become resolved. Given that firms often react to changing energy prices by investing in equipment and improving their operating processes, those that produce energy-efficient equipment are also well placed to leverage higher energy prices as a competitive advantage.

The Panel concluded that the risks associated with rising energy prices were likely to be most serious for those firms using oil-based products and with a limited ability to switch to other fuels. Manufacturing, which tends to use electricity and natural gas in the production process, will not be as directly affected as transportation services, for example, but the higher cost of transportation services will feed through to all firms moving products to market. The transportation services industry will itself be challenged by the higher price of oil but may increasingly find opportunities to substitute natural gas or electricity as relative prices change and technology permits.

In general, the availability of increased energy supplies in the United States may alter Canada's economy in several respects. First, most of its energy exports have traditionally headed south of the border, but the demand for these exports will decline. Second, Canadian firms have been partly sheltered from changes in global energy markets because the abundance of energy sources in Canada has kept prices relatively low. Although adjusting to shocks in global energy markets has been challenging, Canadian firms have adapted and energy-intensive sectors have generally performed well. However, many observers believe that the greater abundance of energy in the United States will support increased opportunities for U.S. firms in manufacturing and this may result in new competitive challenges for Canadian firms.

FINAL REFLECTIONS

Overall, the evidence suggested that Canadian firms have been successful in adapting to changing energy prices in the past. When coupled with the lower levels of energy prices faced by many Canadian firms, the impact of changing energy prices has not undermined the competitiveness of exposed sectors. Canadian firms, for the most part, have been resilient. Where challenges have been evident, they have often resulted from factors other than energy price changes.

Past experience, however, does not guarantee continued resilience in the future as energy markets become increasingly complex. Traditionally, firms may have invested in more modern equipment or improved their operations to improve their energy efficiency. Now, a range of technologies can be employed to take advantage of different energy sources. The outlook, however, for the prices of different sources of energy is diverging.

A compelling conclusion of the Panel's work is that there is a link between having good and timely information and the preparedness of firms to adjust to changing energy markets. Firms that are exposed to energy price increases or volatility can improve their preparedness to act by investing in information,

including benchmarking information, and specialized resources focused on the financial and technical implications of energy prices for their business. But, in interpreting this evidence, it must be recognized that energy prices, while important, are only one element in complex business decisions.

Based on its experience in responding to the charge, the Panel identified several issues that were out of scope for this assessment or for which evidence was not available, but which may well be worth pursuing in a future research agenda:

- the impacts of new technologies on energy choices, in particular those related to the ability to substitute away from oil to electricity or natural gas in transportation, but also those that can mitigate the environmental and safety concerns in developing fossil fuels;
- the opportunities for Canadian firms through development of alternative sources of energy and new ways of using energy;
- the implications for Canada of greater energy abundance in the United States such as the prospects for export markets and the competitiveness of energy-intensive firms in the United States versus Canadian competitors; and
- the specific information, data, and skill sets needed for business to adjust to and capitalize on a more complex energy future, the barriers to gathering and accessing such information and skill sets, and potential strategies to eliminate such barriers.

Glossary

Adaptability – Actions taken and strategies employed directly by firms in response to changing and volatile energy prices. Adaptability is enhanced by preparedness and is an important aspect of resilience.

Elasticity – The ratio of the percentage change in one variable relative to the percentage change in another, thereby measuring the responsiveness of the first variable to a causal impact of the second. For example, the price elasticity of a product is the percentage change in the quantity demanded of a product in response to the percentage change in its price. An elastic (inelastic) product is one where the percentage change in the quantity demanded is greater (less) than the percentage change in price.

Energy Conservation – The reduction in the total amount of energy consumed after undertaking a "conservation action." As such, energy conservation may or may not be associated with increased energy efficiency or reduced energy intensity, depending on how demand for energy services changes.

Energy Efficiency – The energy services provided or physical goods produced per unit of energy input.

Energy Intensity – The cost of energy input per unit of economic value. For individual industries or sectors, this is measured as energy used per unit of gross output, and for the economy it is measured as the ratio of energy expenditures per unit of gross domestic product.

Exposure – The Panel's definition of industrial sectors that are exposed to energy prices includes energy-intensive industries, whose energy intensity is greater than 5%; capital-intensive industries, where capital services are 40% or more of gross output; and the transport equipment sector because the goods produced by this sector consume significant amounts of energy.

Preparedness – The degree to which firms are ready to adapt to changing and volatile energy prices. The Panel's indicators of preparedness consist of the availability of timely, accurate, and relevant information about the evolution of energy markets; benchmarking data; and personnel specialized in understanding the implications of energy for the firm. There is a link between these indicators of preparedness and firm adaptability. Moreover, business demand for these components is increasing in the degree of firm exposure to energy prices.

Primary Energy – Sources of energy that can be extracted or captured directly from natural resources. These include, for example, crude oil, natural gas and natural gas liquids, thermal coal, hydroelectric power, nuclear-generated electricity, and electricity produced from renewable sources.

Resilience – The capacity of a firm, an industry, or group of industries to adapt and adjust to (or "bounce back" from) adverse energy-related events. Past and future resilience can be explored by looking at historical data and indicators of preparedness, respectively.

Secondary Energy – Secondary energy denotes electricity produced from primary sources or energy carriers produced from primary sources. These include, for example, electricity produced from oil, natural gas, or coal, as well as refined petroleum products made from petroleum crude or hydrogen made from reforming natural gas.

Vulnerability – Sectors where exposure to energy prices may lead to negative competitiveness and other impacts.

Table of Contents

List of Figures

List of Tables

1

Introduction

- Charge to the Panel
- The Panel's Approach and Methodology
- Organization of the Report

1 Introduction

Canada has abundant energy sources, from vast oil sands to ample hydroelectric capacity, offshore oil, natural gas, and coal. Nonetheless, Canadian firms have faced rising and volatile energy prices for quite some time. Over most of the last decade, prices for some energy sources increased because of greater demand for energy in rapidly growing developing economies in Asia. This increase has benefitted firms that produce or explore for energy, or those that could help other firms limit their exposure. The onset of the recession in 2008 brought this rise to a halt, but started a period of price volatility for many types of energy. In July 2008 crude oil skyrocketed to nearly US$150 a barrel; by December 2008 the price had plummeted to around US$30.

Although energy prices have fallen back from their 2008 peaks, the recovery of the global economy may again lead to higher energy prices over the next decade. Growth in Asia is projected to be a driving force for energy prices going forward, particularly for oil-based products. An offsetting factor that has emerged over the last few years is the technological breakthroughs in extracting oil and gas from rock formations, particularly in North America (e.g., shale gas; tight oil, synthetic crude oil derived from oil shale; and oil sands bitumen). With the extent of natural gas markets limited by the availability of transportation infrastructure, natural gas prices have dropped significantly on the continent. This newfound abundance has led to natural gas prices decoupling from their traditional linkage, based on energy equivalency, to the price of oil.

These new reserves of energy have transformed energy markets, particularly in the United States. By driving global trade in energy, U.S. demand has traditionally been a leading factor in determining trends in global energy prices. However, increased domestic production will reduce its need to import energy from all countries. As the principal export market for Canadian energy, this impact will be particularly profound for Canada if it is unable to find alternative markets.

A range of other factors will also have an impact on energy prices going forward. Not only will energy price dynamics shift in response to increased supply of oil and gas in North America, but over the long term they will also be affected by increased environmental regulation — whether for shale gas or greenhouse gases — and technology advances for promoting energy efficiency and developing alternative energy sources. Constrained infrastructure to transport new energy sources suggests supply disruptions would feed into heightened price volatility with limited time for firms to prepare and react.

Taken together, these factors create uncertainty over the future evolution of energy prices. For firms tied to extracting energy, this evolution will affect incentives to explore for new fossil fuel reserves in Canada. Since energy is more important as an input cost for many firms, changes in energy prices will also create incentives to pursue a range of strategies to limit impacts on overall operating costs. In this way, energy prices influence business decisions on what types of energy to use and equipment to buy. For firms producing goods and services that may be complements to or substitutes for energy, there will be incentives to make products more energy efficient or to develop new products to exploit new markets in response to higher energy prices.

1.1 CHARGE TO THE PANEL

In July 2012, seeking an evidence-based assessment of business decision-making around energy prices, the Minister of Industry, on behalf of Industry Canada (the Sponsor), asked the Council of Canadian Academies (the Council) to answer the question:

> *What are the opportunities and risks to Canada related to the potential for sustained higher energy prices?*

The charge was further specified in four sub-questions:

1. *Looking forward, what are the expected impacts of higher energy prices on Canadian businesses?*
2. *How do Canadian businesses compare to foreign competitors in terms of their ability to adapt to a) sustained higher energy prices? b) energy price volatility episodes?*
3. *Which industry sectors and communities are inherently a) most vulnerable to higher energy prices? b) best equipped to leverage higher energy prices as a competitive advantage?*
4. *How prepared are industry sectors and communities to capitalize on opportunities or mitigate risks that result from higher energy prices?*

To address the charge, the Council assembled a multidisciplinary panel of 13 Canadian and international experts (the Panel) from academic, business, and public sectors. Panel members were chosen for their expertise and experience. They served on the Panel as knowledgeable individuals in their own right, not as stakeholders for their region or area of expertise. Between January 2013 and February 2014 the Panel met in person five times, as well as several times via teleconference.

At the beginning of the assessment process, the Panel met with senior representatives from Industry Canada and Natural Resources Canada to ensure a common understanding of the charge. The Sponsor and the Panel agreed that the overall charge to the Panel could be summarized as an assessment of the impact of energy prices on Canadian firms, particularly to understand how changing energy prices affect business decision-making. The Sponsor gave further direction on the scope of the assessment:

- The assessment should be business-centric, with an emphasis on the goods-producing sector (rather than the service sector). The focus is on energy as an input, not as an output. Thus, for example, the energy sector may be included because of its high energy use, and not because it produces energy. In addition, some firms, such as in the automotive industry, sell energy-intensive products and are indirectly affected by changing energy prices. These are also in scope.
- The charge does not include direct consideration of carbon pricing, Dutch disease,[1] or social and consumer impacts of energy price changes.
- Although the charge specifically asks about higher energy prices, the Panel can consider changes in energy prices, not necessarily only higher prices.
- All energy sources are to be considered, and regional dynamics within Canada may be part of the assessment.
- The term *communities* in the charge refers to industry communities, not to municipalities or other social communities.

1.2 THE PANEL'S APPROACH AND METHODOLOGY

In response to the charge, the Panel sought to develop an evidence-based assessment of the impact of changing energy prices on energy use and decision-making of Canadian firms. The Panel chose to focus on medium-term business decisions in the context of energy prices and use over a period of approximately 10 years. When making decisions on large-scale energy-related investments, firms evaluate costs and benefits over a number of years, if not decades. Large-scale projects typically must pass several levels of approval by government, and building complementary infrastructure also requires time. Furthermore, changes in energy prices create incentives for researchers, entrepreneurs, and others to develop new technologies, which also require time to develop and

1 In this context, Dutch disease refers to a potential relationship between rising prices of natural resources and a short- to medium-term decline in manufacturing output, as mediated by an appreciation in the exchange rate.

test before commercial application. Taking into consideration the time needed for decision-makers to act and implement these decisions, the Panel decided to adopt a medium-term timeframe (up to 2025) for its analysis.

The Panel also decided to adopt a sectoral approach in its examination of the performance of Canadian business. While it is difficult to predict how individual firms will respond to changing market conditions, the pattern of response can be analyzed within different sectors, which group firms by common characteristics such as the type of technology they employ.

To increase its understanding of business decision-making, the Panel adopted a three-pronged approach to evidence gathering. First, the Panel examined research undertaken in Canada and abroad on how firms have reacted to changing energy prices in the past including peer-reviewed literature in economics, management, and engineering; and reports developed by governments and organizations such as the Organisation for Economic Co-operation and Development (OECD), and the International Energy Agency (IEA). This review and analysis yielded insights into the strategies that firms adopt in the energy context. Importantly, it highlighted eight sectors in Canada that are *exposed* to changing energy prices. The Panel interpreted exposed as the likelihood of there being significant impacts on economic output as a result of changes in energy prices — whether positive or negative — as demonstrated by the empirical literature. The Panel added two sectors that it deemed not to be exposed energy prices to its analysis as a control group.

Second, based on this understanding of sectoral exposure to energy prices, the Panel focused on economic data at the sectoral level, which led to its development of brief sector profiles to assess past resilience — an examination of how each of the 10 sectors had adjusted its energy use in the past in response to price changes. These assessments were enriched by the peer-review process and illustrative examples. The Panel was unable to find comprehensive international data developed on a comparable basis that would enhance understanding of where Canadian sectors stood relative to sectors in other countries.

Third, to explore management practices in the face of changing energy prices, and firm preparedness for such changes in the future, the Panel commissioned a new survey of Canadian firms on business decision-making in spring 2013. It surveyed chief executives, business owners, or other relevant senior executives

at more than 1,000 firms. The survey was designed to elicit a robust sample of firms from each of the eight exposed sectors, as well as the two additional sectors deemed not to be exposed to energy prices.

Taken together, these three types of evidence enabled the Panel to gain a greater understanding of the relationship between energy prices and firm decision-making in Canada, in particular how resilient Canadian firms would be to future changes in energy markets, and potential strategies to improve their preparedness.

1.3 ORGANIZATION OF THE REPORT

The report is organized as follows:

Chapter 2 provides a broad context for the assessment, including background information on Canadian and global energy prices and the energy price scenario adopted by the Panel for its analysis. It also considers other factors that may affect the price scenario over the coming decade (2015–2025), including the potential for developing additional natural gas and offshore oil resources; the ongoing debate about transportation infrastructure, particularly pipelines; environmental and safety concerns related to production, transmission, and consumption of gas and oil; and development of new technologies.

Chapter 3 focuses on the range of decisions firms would be expected to make in response to energy price changes. The Panel uses economic and management theory to highlight the expected strategies of firms, and empirical literature to determine what has actually happened in the past in Canada when energy prices have changed. Drawing on this literature, the chapter identifies the exposed sectors to energy prices (i.e., the most likely to experience impacts as a result of energy price changes).

Chapter 4 takes a closer look at the exposed sectors identified by the Panel, drawing on available economic and energy statistics as well as other information to evaluate their resilience to higher energy prices in the past. The focus is on assessing how the energy intensity of production evolved historically, by sector, in relation to energy price developments. The chapter also examines the available international data on business use of energy.

Chapter 5 introduces the baseline findings of the Panel's survey of Canadian firms. It begins by reviewing the design and structure of the survey, key characteristics of survey respondents, and some of the factors to be considered in interpreting

the results. It goes on to present the overall results for past responses of firms to energy price increases and the availability of specialized staff and access to information on energy markets and benchmarking data.

Chapter 6 presents and analyzes the survey results by sector. It assesses the extent to which Canadian firms would be affected by changing energy prices, and how prepared they are to adapt to these changes to ensure their future resilience. The chapter considers both the risks and opportunities created by changing prices across sectors.

Chapter 7 synthesizes the findings from the three sources of evidence to provide a brief summary of the answers to the main question and sub-questions that comprise the charge. The chapter also offers the Panel's final reflections.

2

The Broader Energy Context for Canadian Firms

- Canada in the Global Energy Context
- Business Energy Use in Canada
- Energy Prices: Historical Trend and Volatility
- EIA Energy Price Projections to 2025
- Recent Energy Developments and Other Scenarios
- Conclusion

2 The Broader Energy Context for Canadian Firms

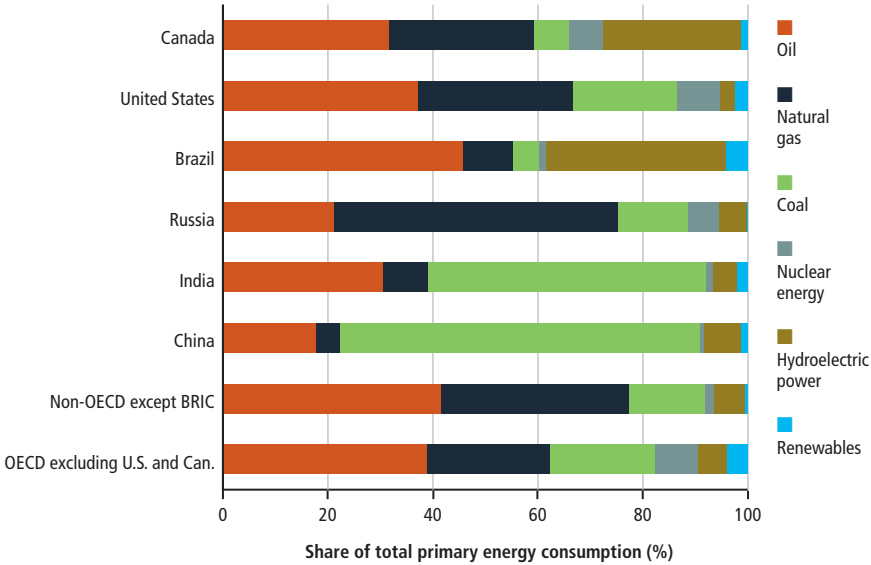
Key Findings

- The traditional risks from energy markets result from significant changes in prices. If energy prices increase, firms producing energy benefit while firms that use energy are concerned about adverse impacts. However, new risks are arising from the increased complexity of energy markets.
- A range of factors will affect energy markets going forward including technological advances in energy efficiency, alternative energy sources, and technological solutions developed in industries not linked traditionally with energy markets. Increased environmental and safety regulations, such as for shale gas or greenhouse gases, will also be a consideration for Canadian firms. The significantly lower natural gas price in North America compared with oil has led to a decoupling of prices for energy sources.
- As the principal export market for Canadian oil and gas, the United States' increased supply of oil and gas will have a profound impact on Canadian energy exporters and energy-intensive producers as U.S. demand for energy imports lessens.
- Business decision-making in Canada is becoming increasingly more challenging as a result of these risks. Future drivers and impacts of decision-making will reflect more than just rising energy prices.

The chapter examines trends in global and Canadian energy markets to provide the broader energy context in which Canadian firms operate and make decisions. It begins with a look at historical patterns of energy use in Canada and of prices for oil, natural gas, and electricity. The Panel then examines the likely path of energy prices in the future. In keeping with its focus on the energy prices in the medium term, the Panel uses price projections to 2025 in the Energy Information Administration's (EIA) reference case (developed in the United States) as a reasonable central benchmark to frame its analysis. In an exploration of the implications of these projections for Canada, the Panel identifies a number of global trends that could potentially alter these projections. This analysis generates insights into potential risks and opportunities for Canadian firms as a result of these trends.

2.1 CANADA IN THE GLOBAL ENERGY CONTEXT

The world uses energy from a range of sources including coal, crude oil, and nuclear-powered electricity as well as renewable sources such as hydroelectric power, solar, and wind. Oil is the largest single source of primary energy in most countries. Coal has been a major source of energy traditionally, particularly in generating electricity, and continues to be a major source of primary energy, particularly in the United States, India, and China. Canada is among a small group of countries, including Brazil, for which hydroelectric power is important. Figure 2.1 shows primary energy sources for Canada, the United States, the OECD group of industrialized economies, and BRIC economies.



Data Source: Panel calculations based on BP (2013)

Figure 2.1

Consumption of Primary Energy, OECD and BRIC Economies, 2012

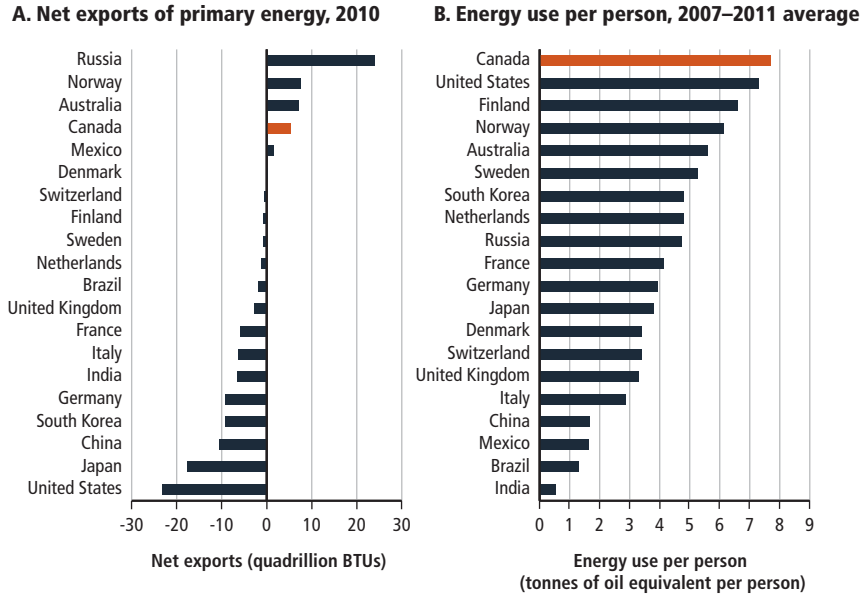
This figure shows the main sources of primary energy. Oil is the main source of energy in the OECD, but coal is used extensively in the United States, China, and India. Canada and Brazil use proportionately more hydroelectric power. BRIC refers to Brazil, Russia, India, and China.

Energy sources are distinguished by their physical characteristics, which affect their usefulness as sources of energy and thus their prices on world markets (Cleveland, 2007). The ability to store energy is also important, placing fossil fuels at an advantage in generating electricity compared with many types of clean energy that lead to more intermittent supply. Physical characteristics of a fuel affect the extent to which it can be traded, thus affecting energy market structures. For example, since transmission losses imply costs for long distance transportation of electricity, the geographic spread of electricity markets is constrained. In contrast, a global market exists for oil because it can be transported around the world in tankers or over land by pipeline or rail. Historically, natural gas has tended to be transported through pipelines, thus limiting its markets to contiguous land masses. Although the capacity to liquefy natural gas has been around for decades, tankers that transport liquefied natural gas (LNG) are now bringing markets together. With these physical trade limitations, the degree of international trade in energy tends to reflect the availability of oil reserves or the crossing of contiguous international borders, such as the north-south trade in electricity in North America.

A distinguishing feature of Canada is that, along with Norway, Australia, and Mexico, it is one of the net energy exporters in the OECD. Panel A of Figure 2.2 shows that other developed economies are net importers of primary energy. Although the United States is a major producer, it currently consumes far more than it produces. Among the four BRIC countries (Brazil, Russia, India, and China), Russia is a major energy exporter whereas India and China are major importers. Brazil is currently developing its deep-water pre-salt oil fields.

Canada also stands out by having the highest energy use per person in the OECD. Panel B of Figure 2.2 shows average energy use per person across 2007–2011. Since they have greater access to transportation and use more capital equipment, developed economies tend to have higher per person use of energy than developing economies, such as China and India.

A number of factors contribute to Canada's ranking including climate, which creates the need for heating and cooling; country size, which creates the need for transportation; and industrial structure, including being an energy exporter. Relatively low prices for energy sources lead to an industrial structure that is relatively more energy intensive and a net exporter of energy-intensive goods. At an aggregate level, such comparisons of energy use are interesting, but do not by themselves provide evidence of inefficient energy use or opportunities for improvement.



Data Source: Panel calculations based on EIA (2014b) and OECD (2014)

Figure 2.2

Net Exports of Energy, 2010, and Energy Use Per Person, Selected Economies, 2007–2011

Canada is one of the few net exporters of energy among OECD economies. Its production of energy, its climate, and geographic size play a part in accounting for its high level of energy intensity.

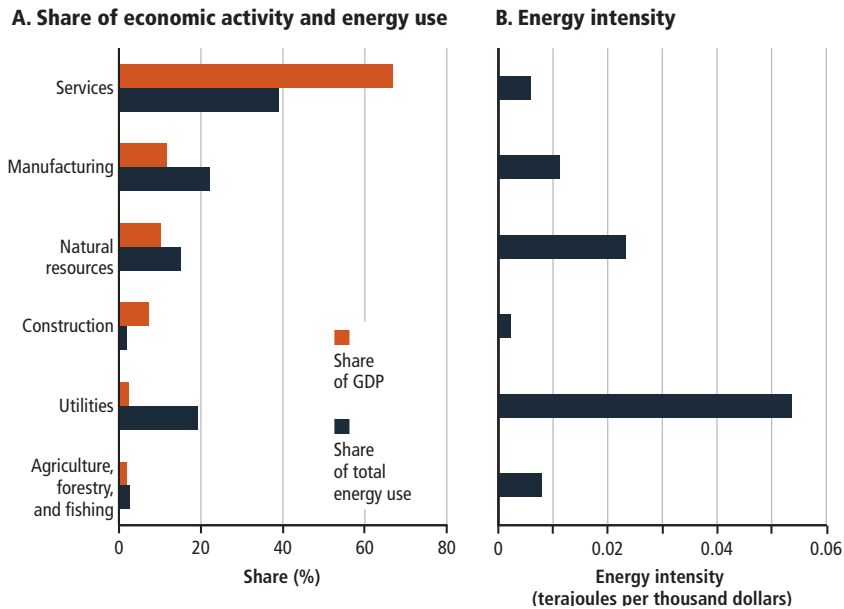
2.2 BUSINESS ENERGY USE IN CANADA

The business sector has accounted for just less than three-quarters of total energy demand in Canada over the last two decades (Statistics Canada, 2014a), and accounts for around 70% of gross domestic product (GDP).[2] The intensity of energy use differs across industrial sectors, where intensity is measured as energy used per unit of value-added production. Manufacturers, for example, tend to use more energy than retailers from the service sector because they use a significant amount of electricity to power machines in addition to what is needed to heat and light their buildings. Hence, while the service sector as a whole accounts for two-thirds of the Canadian economy, it accounts for less than 40% of national energy use (see Panel A, Figure 2.3). The sector's

2 The business sector extends to all facets of the Canadian economy other than public administration, non-profit organizations, and the Canadian System of National Accounts imputation of the rental value of owner-occupied dwellings (Industry Canada, 2014a).

energy intensity is therefore much lower than that of other sectors (see Panel B, Figure 2.3). The utilities sector includes the electricity generation industry, which itself produces energy but consumes large amounts of energy in order to do so. As a result, its energy intensity is much higher than that of other sectors. Energy intensity is highest in the utilities, natural resources, and manufacturing sectors, as shown in Figure 2.3; they account for a greater share of energy use than their share of economic output.

The sectoral differences in energy intensity mean that the potential challenges and opportunities created by changing energy prices also vary by sector, as does the ability to respond to the changes. For this reason, along with the tendency of firms within the same sector to respond to changing energy prices in similar ways, the Panel chose a sectoral basis to structure its analysis of business decision-making in response to changing prices (as discussed in Section 1.2).



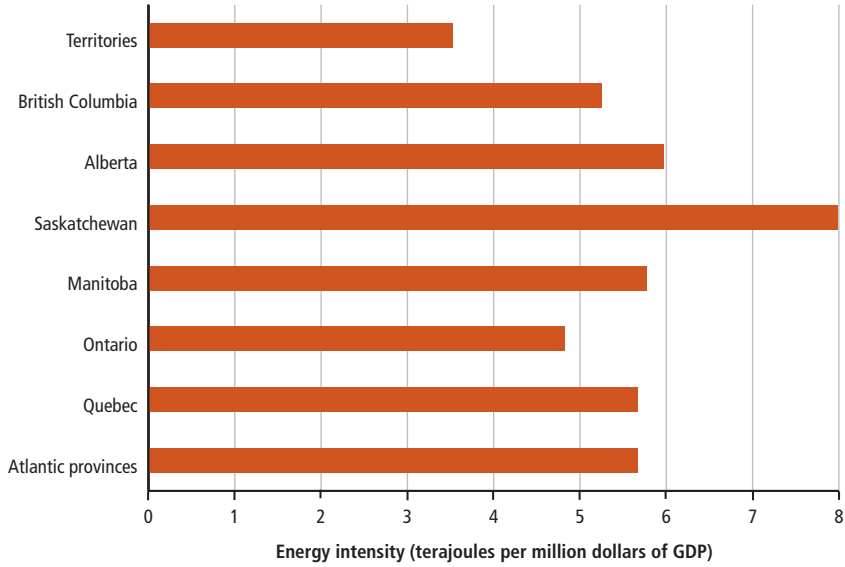
Data Source: Panel calculations based on Statistics Canada (2014a, 2014b)

Figure 2.3

Share of Energy and Economic Activity, and Energy Intensity, by Sector, Canada, 2008

Energy intensity is higher in sectors such as utilities, natural resources, and manufacturing, as shown by these industries' greater share of energy use compared to their share of economic output. Sectors are ranked by share of gross domestic product (GDP).

The impact of changing energy prices varies not only by sector but also geographically across Canada (see Figure 2.4). In part, the distribution of sectors across provinces accounts for their varying energy patterns. Furthermore, the different sources of energy used in provinces and their availability are also important.[3] Although Alberta and Saskatchewan are widely recognized as energy producers, cheap hydroelectric power in Quebec means that its economy is also relatively energy intensive. The relative abundance of hydroelectric power has affected provinces' energy policies in the past, lowering prices where hydroelectric power was abundant and encouraging the development of other sources where it was not. However, the sources of cheap hydroelectric power have largely been exploited in many provinces in Canada, and potential new sources will incur significant transmission cost. Prices for electricity in the future will increase as the marginal cost of more expensive sources are blended into the regulated price or reflected in wholesale and retail prices, depending on the jurisdiction.



Data Source: Panel calculations based on Statistics Canada (2014c, 2014d)

Figure 2.4

Energy Intensity by Canadian Province, 2008

The distribution of industries and the abundance of energy sources are factors that alter energy intensities across provinces. There are also significant differences in the energy sources used across provinces. *Energy intensity* is energy used in final demand of both primary and secondary energy measured in terajoules divided by GDP at basic prices in millions of dollars. Basic prices are the prices that producers receive for selling a product, such as after paying taxes, receiving subsidies, and excluding transport charges.

3 Alberta and Saskatchewan tend to use more natural gas while many other provinces tend to use hydroelectric power (Statistics Canada, 2014e).

2.3 ENERGY PRICES: HISTORICAL TREND AND VOLATILITY

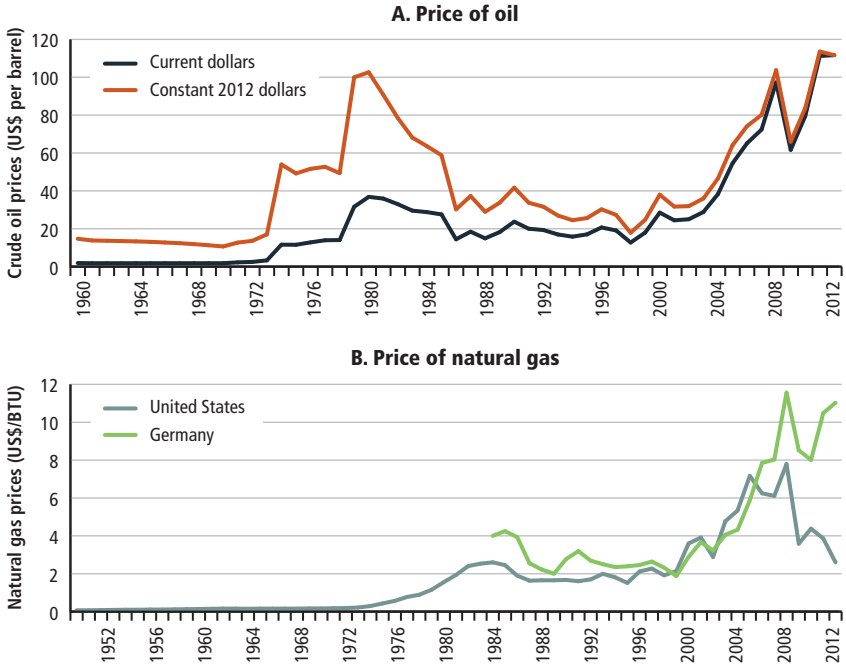
The use of different types of energy is affected by their price. Historically, oil and gas prices have tended to move together in Canada. The cost of natural gas or crude oil in provinces without their own reserves has been increased by the costs of transporting the fuels. Electricity prices, however, have varied by province because of differences in government policies and the relative abundance of hydroelectric power.

Because of these differences, this section looks at international trends in prices of oil and natural gas, but examines in more detail North American trends in electricity prices.

2.3.1 Oil Prices

Each energy source has its own price dynamic, but price movements over the long term have been influenced by the price of oil. The centrality of oil, as both a source of energy and in linking economies, has meant that fluctuations in its price have had macroeconomic consequences (Hamilton, 2008). The world price of crude oil was relatively constant until the early 1970s when global political and economic changes led to a period of volatility. Panel A of Figure 2.5 shows the price of oil in nominal and real terms. Panel B shows that natural gas prices in Germany and the United States tracked closely until extensive exploitation of shale gas in the United States caused the price of gas there to decouple from the price of oil. The price of natural gas in Germany has continued to track the price of oil.

Figure 2.5 also highlights the oil price volatility that has occurred since 2008 as growth in developing economies first boosted long-term demand, but then coincided with the global recession curtailing demand. Volatility can be defined in several different ways. Panel A of Figure 2.6 shows that volatility, as defined by the level of month-on-month change in oil prices, has increased. However, these absolute monthly changes are associated with a rising mean price of oil. When this is normalized, as shown in Panel B of Figure 2.6, the relative volatility appears more contained.



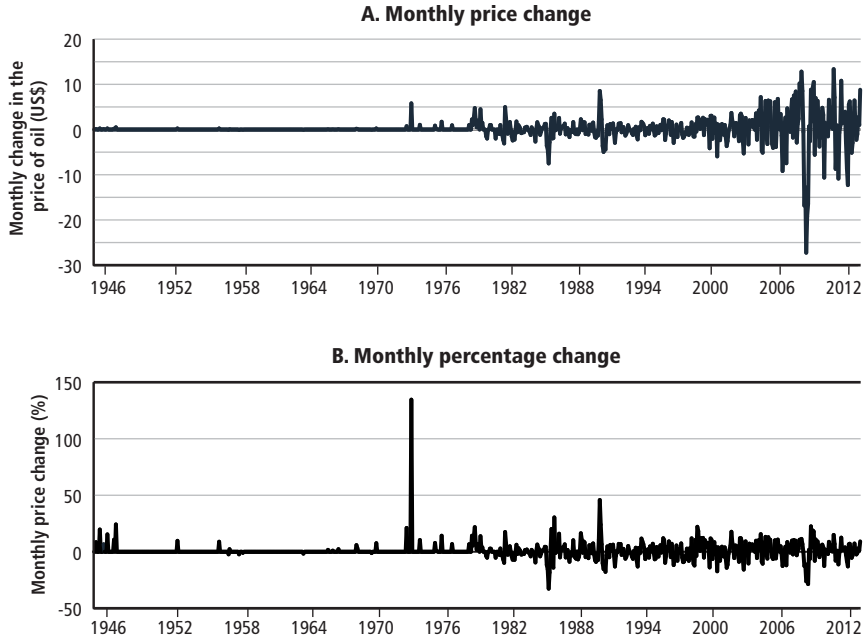
Data Source: BP (2013) and EIA (2014c)

Figure 2.5

Oil and Natural Gas Prices, 1950–2012

The price of oil reached new highs in nominal dollars around 2008, but is around the same level as in the late 1970s after accounting for inflation. The price of natural gas in Germany tracked the price of oil, but the increased abundance of natural gas in North America led to the price of natural gas in the United States decoupling from both the price of oil and the price of natural gas elsewhere. Oil price data for 1961 to 1983 are for Arabian Light oil. Data for 1983 to 2012 are for Brent oil. Natural gas price for Germany is the average German import price in U.S. dollars per million British thermal units (BTUs), and is available from 1984 onwards. U.S. natural gas wellhead prices have been converted to BTUs.

Dvir and Rogoff (2009) find that the rapid industrialization of Asia beginning in the 1970s played a role in the step increase in volatility from 1972 because increased and unanticipated demand spurts do not translate immediately into increased supply, as explored further by Foote and Little (2011). They also suggest that with continued growth in Asia likely over the coming years, it is possible that volatility will be a continuing feature of energy markets.



Data Source: Panel calculations based on Federal Reserve Bank of St. Louis (2013)

Figure 2.6

Monthly Volatility in Oil Price, 1946–2012

This figure shows West Texas Intermediate (WTI) spot monthly changes in level and percentage terms. As the price of oil increased, the magnitude of the monthly price swings has increased. However, the changes have stayed relatively constant in percentage terms since the 1970s.

2.3.2 Natural Gas Prices

Changes in oil prices have traditionally spilled over into other energy prices because of the ability to substitute between different types of energy sources. As a result, market forces have made the prices of other energy sources move in lockstep with oil prices over long periods of time. However, local circumstances can lead to price divergence because of the limits on the ability to trade and store those other energy fuels, and because energy sources do not always exactly replace each other. A notable recent example is the price of natural gas.

By convention, the unit of measurement for natural gas is in terms of energy units (such as gigajoules (GJ) or British thermal units (BTUs)) rather than in volume terms (such as barrels), the unit of measurement for oil. These measurements can be made compatible by comparing the amount of energy released when the fuels are burned. The energy content of a barrel of oil is

roughly 5.8 million BTUs of energy.[4] Figure 2.7 shows the price of oil relative to natural gas on this comparable basis. Until the end of the last decade, the prices of oil and natural gas had been roughly equal in North America, suggesting there was no significant incentive to switch from one fuel to the other if they were burned to generate energy.

However, Figure 2.7 also highlights that energy sources are not always substitutable in the short run. Technological change in extracting natural gas increased its supply in North America so that natural gas became less expensive relative to oil. Over a longer period of time such disparities may not persist, as firms adjust the mix of energy they use to take advantage of the lower relative price of gas and as new infrastructure expands markets. How long any differences will persist is a difficult question, with real implications for business decisions. The evidence reviewed by the Panel suggests that oil and gas prices in North America

Data Source: Panel calculations based on EIA (2014d, 2014e)

Figure 2.7

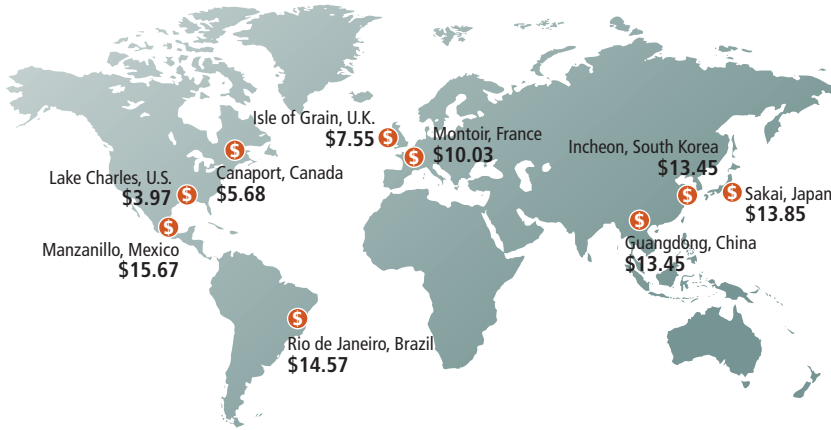
Price of Oil Relative to Natural Gas in North America, 1997–2013

The price of oil relative to natural gas was relatively constant in North America at around their energy-equivalent basis. Technological breakthroughs in natural gas extraction then led to the price of natural gas declining relative to oil. Price data have been adjusted to reflect that 1 barrel of oil has an energy content of 5.8 million BTUs. The natural gas price is the spot price at Henry Hub. The oil price is spot WTI price at Cushing, OK.

4 Although a barrel is a standard unit, the crude oil contained in it may have marginal differences in energy content.

are not likely to converge significantly within the next decade. However, the uncertainty generated by increased availability of natural gas is reflected in the rebound in its price in the second half of 2012 (Figure 2.7).[5] When the price dipped below US$2 per million BTU in the first half of 2012 as a result of the likelihood of increased supply, many existing reserves were rendered uneconomic (EIA, 2014a).

This divergence in prices has not been reflected in other countries because of limits on capacity to transport natural gas. Figure 2.8 shows the different prices for LNG at ports around the world. Although the wide variation in prices suggests unmet opportunities to exploit international price differences, significant capacity to export is currently being built in Australia, making it unclear whether these price disparities will remain. Australia is reported to be spending A$200 billion to increase its current A$12 billion exports five-fold by 2017–2018 (The Economist, 2013).



Data Source: IHS Energy (2014)

Figure 2.8

World Estimated Landed Prices for LNG, June 2014

The figure shows the prices of natural gas at ports around the world. Wide differences in prices suggest that markets for natural gas are not globally integrated because of the absence of sufficient transport capacity. Prices are for LNG landed prices in U.S. dollars per million BTU.

5 The price of oil had remained relatively constant over this period.

2.3.3 Electricity Prices

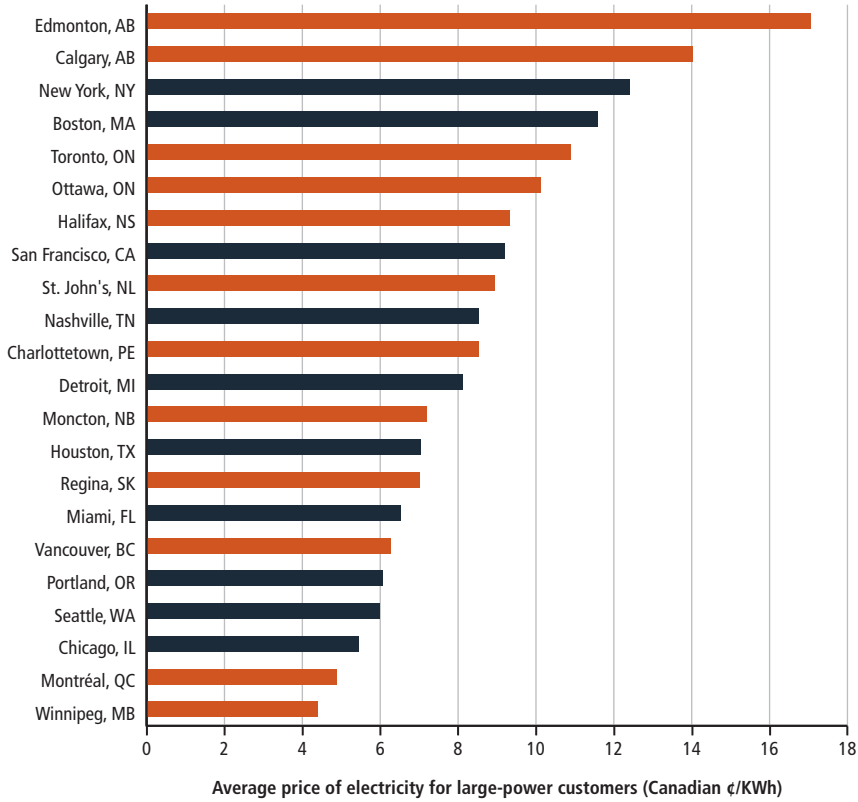
Electricity is an important type of energy, but it differs from other types of energy both in market size and structure. In North America, electricity is a regional market in which most major electricity transmission interconnections are north–south rather than east–west. The sources of energy used for electricity generation also vary by region. Hydro accounted for more than 90% of electricity generated by utilities on average in 2005–2012 in Newfoundland and Labrador, Quebec, Manitoba, British Columbia, and Yukon (Statistics Canada, 2014e).

Governments in Canada have traditionally played a considerable role in determining electricity prices. In most provinces electricity prices are set by the electricity regulator, but some have restructured their electricity market to allow market forces to influence the price. Alberta has moved the furthest in this direction while Ontario has undergone a partial restructuring (Goulding, 2013). Large industrial and commercial consumers in Alberta and Ontario buy directly from the wholesale market, and are more likely to be affected by the current costs of generation than to have fixed costs through long-term contracts.[6] Since the 1960s, Quebec has used its control over the production and price of energy in the province to attract industrial development. As a result 47% of electricity in Quebec is used by industry, including energy-intensive industries such as aluminium and paper production (Pineau, 2012).

Goulding (2013) discusses the trade-offs in these provincial decisions including the competitiveness impacts of diverging from neighbouring provinces or states south of the border. Figure 2.9 shows the impact of these different policies on electricity prices for large industrial consumers across North American cities.

The falling relative price of natural gas in North America can feed into the price of electricity because natural gas is an important fuel used to generate electricity, particularly for new power plants. The flexibility of plants using natural gas means that they are more likely to be the source of electricity during periods of peak demand. By contrast, because of their reliance on the weather, renewable power sources such as wind or solar tend to be in intermittent supply, requiring natural gas-powered plants to be on standby when there is a shortfall in supply. Although the price of electricity for households tends to be regulated by governments, changing prices for natural gas can feed through to industrial users of electricity relatively more quickly.

6 In practice, the pricing structure is complicated. In Ontario, for example, business customers that pay the spot market price also pay a global adjustment to reflect the difference "between the market price and the rates paid to regulated and contracted generators, and for conservation and demand management programs" (IESO, 2014).



Data Source: Hydro-Québec (2013)

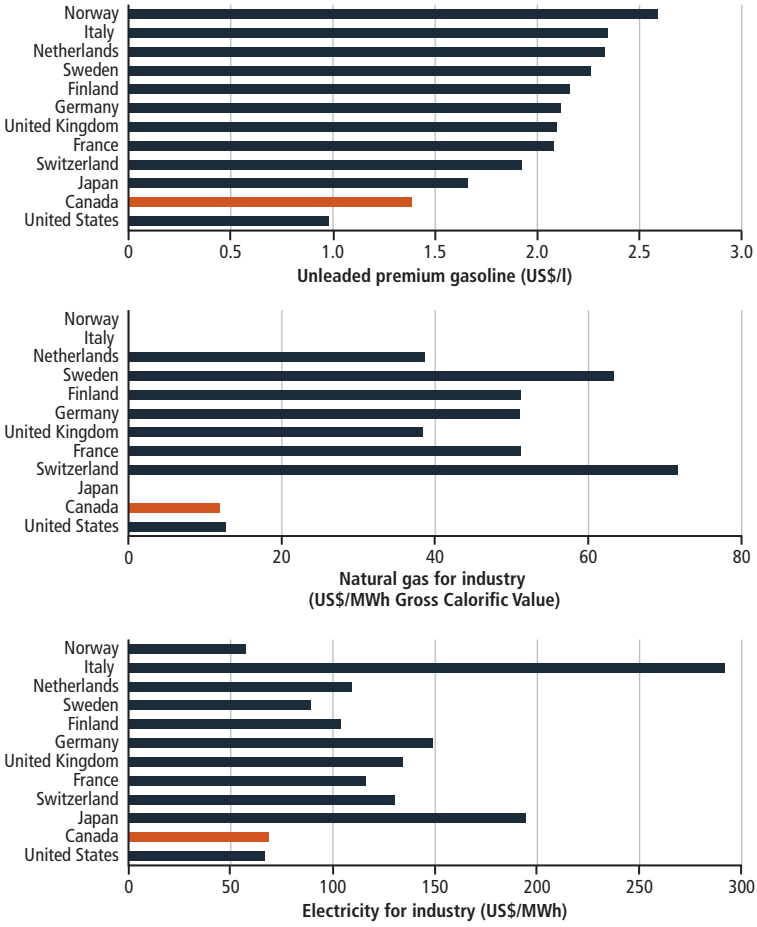
Figure 2.9

Electricity Prices for Major North American Cities, 2012

The figure above shows the average prices for large-power customers (power demand of 5,000 kW) on a supply voltage of 25kV across cities in North America. Prices exclude taxes. The lowest prices are obtained in Quebec and Manitoba.

2.3.4 International Comparisons of Energy Prices

The interaction of global supply and demand patterns, the substitution possibilities between types of energy sources, and the role of government regulations and taxes interact to determine the final price of energy faced by end users. Available data, as shown in Figure 2.10, suggest that, averaged across provinces, energy prices were relatively low in Canada (and the United States) in 2012 compared with other leading industrialized economies.



Data Source: IEA (2013a) and Manitoba Hydro (2013)

Figure 2.10

International Prices of Selected Energy Sources, G7 and Selected Economies, 2012

The figure shows that the prices of various energy sources are low in Canada relative to many other developed economies. Countries are ranked by the price of unleaded premium gasoline. Prices for electricity are not available for Canada from the IEA. They are calculated as a simple average of rates for large industrial loads across utilities in Canada based on data from Manitoba Hydro. Prices for natural gas are not available for Italy and Japan, and not applicable for Norway. No data were available for Australia, which is another major energy producer in the OECD.

2.4 EIA ENERGY PRICE PROJECTIONS TO 2025

Assessing the impacts of energy prices on Canadian business was the central charge to the Panel. To develop a context for its work, and in keeping with its focus on business decisions in the medium term, the Panel used the U.S. EIA reference case to 2025 as its central benchmark (EIA, 2013a). This case was developed in 2013 at the time of the Panel's main work on this report.[7] For more information on the EIA, which is an arms-length statistical and analytical agency within the Department of Energy in the United States, see Box 2.1. The Panel is unaware of any consistent and comprehensive model-based forecast of Canadian energy prices developed and updated annually in Canada.

Box 2.1
The U.S. Energy Information Administration

The U.S. EIA was established legally in 1977 as the main federal government authority on energy statistics and analysis. It "collects, analyzes, and disseminates independent and impartial energy information to promote sound policy-making, efficient markets, and public understanding of energy and its interaction with the economy and the environment." These data, analyses, and forecasts are independent of approval by any other government officer or employee in the United States.

The full spectrum of energy sources, end uses, and energy flows is covered in the EIA's comprehensive data collection program, energy analyses, monthly short-term forecasts of energy market trends, and long-term global and U.S. energy outlooks. The EIA distributes its data, analyses, and other products primarily through its website and customer contact centre.

(EIA, 2014f)

The EIA reference case suggests a relatively limited increase in energy demand in the United States over the period. This potentially reaches "peak demand" in some of the scenarios considered, as total demand stops growing because of improved energy efficiency and demographic changes. For example, in this scenario demand for oil to power transportation (the major user of liquid fuel) remains relatively constant going forward. As the U.S. economy ceases to drive energy demand globally, economic growth in emerging economies such as India

7 The price projections developed in 2014, after this report was prepared for publication, reflect similar trends to those of 2013, but further strengthen the earlier projection of increased domestic supply of energy in the United States.

and China drives prices higher. In this scenario, the price of globally traded crude oil (as proxied by the price of Brent crude) increases by 20% to US$117 in 2025 in real terms (Table 2.1), a trend also reflected in an examination of a wider set of models and projections done by Newell and Idler (2013).

The revolution in extraction technologies means that natural gas production will continue to increase in the United States. Consequently, natural gas prices are projected to remain below US$5 per million BTU in real terms through to 2025.

The EIA projections reflect only policies that are already in place (such as laws and regulations), and therefore assume no new significant global policy to address climate change, for example. Nevertheless, the EIA assumes that coal will not increase its role in electricity production in the United States because of regulatory policies linked to pollution. Coal prices remain below US$3 per million BTU in real terms in the reference case.

Table 2.1

The EIA Projections for Energy Prices, 2013 and 2025

	Prices (2011 US$ per unit)	
	2013	2025
Brent Spot Price ($ per barrel)	97	117
West Texas Intermediate Spot Price ($ per barrel)	88	115
Natural Gas at Henry Hub ($ per million BTU)	3	5
Coal, Delivered ($ per million BTU)	3	3
Electricity (cents per kilowatt-hour)	9	9
	Prices (nominal US$ per unit)	
	2013	2025
Brent Spot Price ($ per barrel)	100	148
West Texas Intermediate Spot Price ($ per barrel)	91	145
Natural Gas at Henry Hub ($ per million BTU)	3	6
Coal, Delivered ($ per million BTU)	3	4
Electricity (cents per kilowatt-hour)	10	12

Data Source: EIA (2013a)

Electricity prices remain roughly constant in real terms for the next decade in the EIA projection. They are also subdued because of excess capacity in generation built up over the last decade in the United States that will not be exhausted until 2025. Two-thirds of the additional capacity is expected to come from natural gas, whose price is expected to remain low, and one-third from renewables (mainly hydroelectric power, wind, and solar). Both wind and hydroelectric power have low marginal cost; however, integrating wind and solar into the electrical grid in large amounts will have operational implications for reliability, which have only recently been recognized and addressed (NERC & CAISO, 2013).

Although the EIA projections are developed with greater attention to energy use in the United States, the price projections are relevant for Canada because the United States is the main destination for Canadian energy exports and, because of its economic size, the United States also plays a role in setting global prices for energy. However, the path of energy prices may differ in Canada. For example, pipeline constraints have held back the price of Canadian crude oil recently. Furthermore, the trend in electricity prices will likely differ by province. Although most provinces suggest that prices of electricity to households will face increases tied to the rate of general inflation in the short term, there are no long-term projections for electricity prices for business with the exception of Quebec (e.g., Hydro-Québec, 2010).

2.5 RECENT ENERGY DEVELOPMENTS AND OTHER SCENARIOS

The EIA (2013a) reference case discussed above is only one of a range of possible outcomes for energy markets. While its projections are used as the basic reference case for this assessment's analysis, the Panel also identified other possible factors that could lead to higher or lower energy prices than projected by the EIA over the medium term. Many of these factors may also generate risks and opportunities for Canadian business, but navigating the complex interplay between these factors will be challenging for business decision-makers.

2.5.1 Growth in Global Energy Demand

As noted previously, economic growth in Asia has been a major factor in accounting for higher energy prices over the last decade. Wolfram *et al.* (2012) suggest that price projections made by organizations such as the IEA and the EIA are likely to be too low, much as projections of energy prices made a decade earlier fell short. In fast-growing developing economies, consumers are purchasing goods like cars, refrigerators, and air conditioners for the first time, which leads to a step increase in energy demand. In contrast, consumers in

OECD countries gradually upgrade to higher-quality but more energy-efficient models when they become wealthier. Growth in such first-time purchases would be particularly rapid if the rate of poverty reduction were to accelerate in emerging economies.

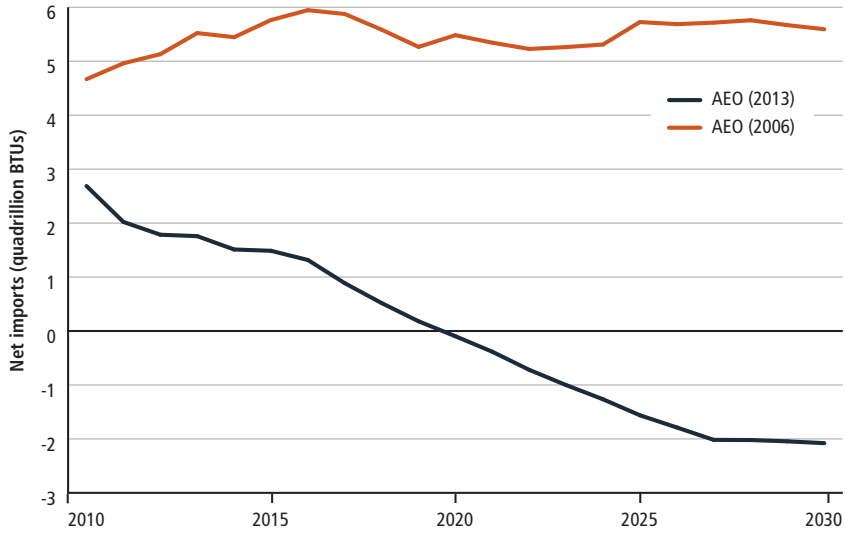
2.5.2 Increased Supply of Natural Gas in North America

During the oil price spikes of 2008, concerns were expressed that the world had reached peak oil production so that supply would diminish over time. These concerns were dissipated as new sources of tight oil and shale gas became available. Between 2000 and 2010 proven reserves of gas increased by 70% in the United States; in 2010 the United States was estimated to hold 5% of world gas reserves (EIA, 2013b). Some doubts remain over how much of these new resources can actually be extracted because of the high decline rates from hydraulic fracturing of wells. However, the geographic areas that have been exploited to date are quite small, which suggests that significant reserves exist (EIA, 2013b). The cost of extracting shale gas could increase as a result of further regulation of the environmental impacts of hydraulic fracturing (CCA, 2014).

Increased production in the United States will limit its demand for oil and gas imports. Figure 2.11 shows that the main EIA reference case developed in 2006 projected continued imports of natural gas into the United States. Today, as a consequence of shale gas production, the EIA projects that the United States will become a net exporter of natural gas by around 2020.

Further technological breakthroughs that increase the supply of natural gas (or tight oil) in North America could alter global energy price patterns further because of diminished import needs in the United States. Panel A of Figure 2.12 shows the projected ratios of the prices of oil to natural gas on an energy-equivalent basis (i.e., after moving to a common unit by adjusting for energy content). It highlights how unanticipated breakthroughs in extracting shale gas can have significant effects. Since the ratio is above 1.0, it suggests that natural gas will remain relatively cheap over the projection period and beyond.

Electricity producers in North America have already turned to using more natural gas for both financial and regulatory reasons (Panel B, Figure 2.12). According to the EIA (2013a), currently available combined-cycle gas turbine power plants have “all-in” costs (including items such as capital as well as energy costs) that are much lower than for conventional coal power plants.



Data Source: Panel calculations based on the Annual Energy Outlook (AEO) from EIA (2006; 2013a)

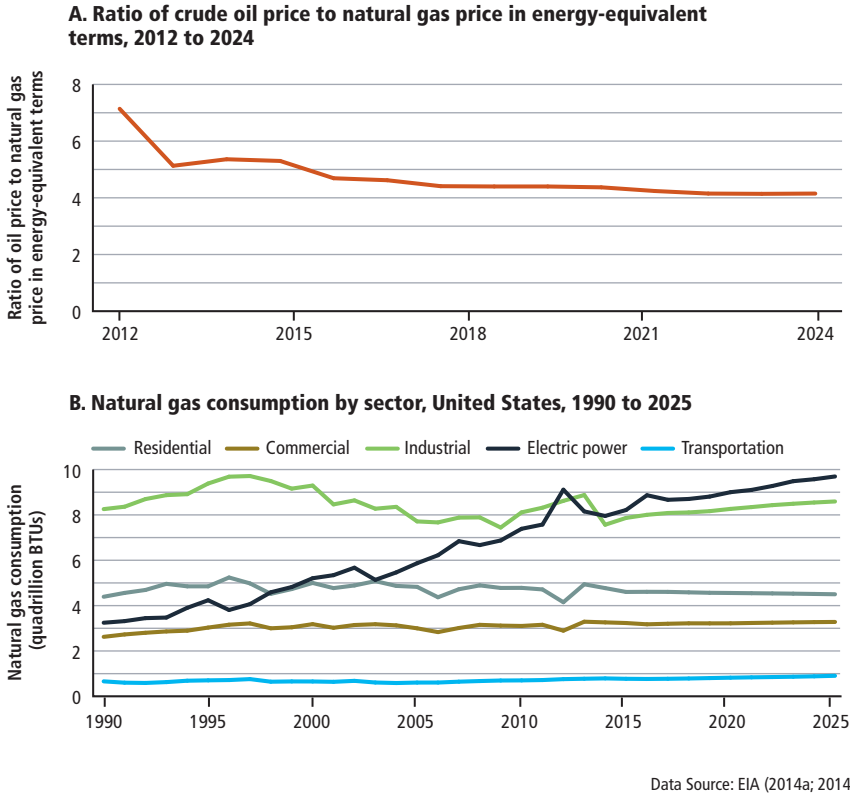
Figure 2.11

EIA Projections of Net Imports of Natural Gas, United States, 2010–2030

Projections made by the EIA in 2006 suggested that the United States would import significant quantities of natural gas. Subsequent technological breakthroughs in extracting shale gas mean that production increased significantly in the United States. As a result, the level of natural gas imports has declined relative to those expecations, and in scenarios developed more recently by the EIA the United States becomes an exporter of natural gas.

The opportunity to use natural gas, however, is much wider than just electricity generation. There are market incentives for firms to switch from burning oil to burning natural gas, to encourage their engineers and researchers to develop technologies that make greater use of natural gas, and to relocate production to North America. Natural gas is generally used as feedstock for chemical firms, and has potential for greater use as a transport fuel through either compressed natural gas (CNG) or gas-to-liquids (GTL) technologies. Although the financial cost of CNG and GTL are currently equal to or lower than gasoline prices, there is a significant cost attached to building appropriate infrastructure (Krupnick, 2012; Knittel, 2012).[8] Section 2.5.4 highlights the implications of pipeline decisions and other infrastructure considerations.

8 In a survey of country experiences and other studies, Yeh (2007) found that adoption of natural gas vehicles beyond their use in fleets (such as taxis) is encouraged by factors such as the natural gas fuel price being 40–50% below gasoline, a payback period of three to four years or less, and a ratio of about 1,000 vehicles per refuelling station. Synthetic fuels tend to have fewer pollutants but generate more greenhouse gases. Schrag (2009) suggests that carbon dioxide emissions per barrel are between 50% and 100% greater for GTL than for petroleum.



Data Source: EIA (2014a; 2014g)

Figure 2.12

Relative Price and Consumption Patterns of Natural Gas, Historic and Projected

The EIA projects that natural gas will remain much cheaper than oil on an energy-equivalent basis until at least 2025. There has already been a significant increase in natural gas consumption in electricity generation. However, the low price of natural gas will create additional incentives to switch to natural gas or to develop new technologies that make use of it. The price of oil is for Brent crude, and the price of natural gas is for Henry Hub.

The EIA (2013a) reference case suggests that the low price of natural gas already makes it financially feasible to power heavy-duty vehicles for private firms: "[i]n the AEO2013 Reference case, fuel switching to natural gas in the form of CNG and LNG already is projected to achieve significant penetration of natural gas as a fuel for heavy-duty trucks. […] The use of natural gas in the Reference case is economically driven. Even after the substantial costs of liquefaction or compression, fuel costs for LNG or CNG are expected to be well below the projected cost of diesel fuel on an energy-equivalent basis." If oil prices were at US$100 per barrel, a GTL plant would break even when natural gas prices were lower than $6 per million BTU. Although the EIA does not currently project significant take-up of natural gas for other modes of transportation (Panel B

of Figure 2.12), the incentive exists for wider adoption of natural gas to power motor vehicles as demonstrated by the extensive penetration of CNG in many countries around the world.[9]

Increased reserves and production of natural gas have lowered the price of natural gas significantly in North America, both absolutely and relative to the price of oil. There is uncertainty about how low the price will remain in the long run as new export markets open for LNG and gas becomes increasingly attractive as a transportation fuel. Nevertheless, over the next decade the Panel believes that gas prices will likely remain low.

In this respect, the increased availability of natural gas in the United States will lower the cost of energy-intensive production there as well as in Canada. Consequently, the competitiveness of firms in the United States will be bolstered. The International Monetary Fund suggests that it is too early to have seen the impact as yet (Celasun *et al.*, 2014). However, McKinsey Global Institute (2013) estimates that shale energy could add 2 to 4% (US$380 billion to US$690 billion) to annual GDP and create up to 1.7 million permanent jobs by 2020. Such a development in the United States could extend the existing productivity advantage of the business sector in the United States relative to Canada, as synthesized in a recent Council of Canadian Academies report (CCA, 2013a).

2.5.3 Increased Exploration and Extraction of Offshore Oil and Oil Sands

The primary opportunity from higher energy prices in Canada will be for those exploring for and extracting energy, which has been traditionally based in Alberta and is growing in Newfoundland and Labrador, Saskatchewan, and British Columbia. The higher price of oil would also increase the potential rewards from exploration, particularly in areas where risks are significant and costs are high, such as in eastern and northern Canada, off the coast of Labrador and into the Arctic. The U.S. Geological Survey estimates that the Arctic contains about 22% of the undiscovered, technically recoverable resources in the world (USGS, 2008).

However, some parts of the industry would benefit from lower energy prices. Although the oil sands industry produces large quantities of oil and would benefit from higher oil prices, it is also a heavy user of natural gas. The *in situ* process of extracting bitumen requires the use of natural gas, and natural gas is used to upgrade bitumen to synthetic crude so that it can be refined further.

9 Yeh (2007) reports that the highest number of CNG vehicles is in Argentina where penetration has reached 17%. It is followed by Brazil, Pakistan, Italy, India, the United States, and China.

2.5.4 Approval of Pipeline and Infrastructure Development

Reserves of Canadian oil and natural gas tend to be far away from major markets, whether in the United States or overseas, and therefore require pipeline capacity to deliver the product. At the time the Panel was preparing this report, the decision on whether to approve many proposals in North America was pending. The Keystone XL pipeline will be important in determining future access to the United States for Canadian crude oil. Other pipeline options are in play, such as the Northern Gateway and Transmountain pipelines to transport oil, condensates, and refined products to the coast of British Columbia. The proposed TransCanada Energy East pipeline would deliver crude oil from Alberta to refineries in eastern Canada (CEPA, 2013).

Although it will take some time for these issues to unfold, how they do will affect the energy future of Canadian business. Over the coming decade to 2025, there will likely be opportunities associated with pipeline construction and other infrastructure requirements associated with transporting energy.

2.5.5 Environmental and Safety Concerns

Future energy markets will be increasingly influenced by environmental and safety concerns that find their expression in government regulation. Some Canadian provinces and many states south of the border have introduced renewable energy portfolio standards that mandate a fixed proportion of electricity to be generated from renewable sources of energy by a certain date (Probst & Szambelan, 2009). Recent regulatory action by the U.S. Environmental Protection Agency will result in the premature retirement of many coal-fired power plants over the coming decade. It is generally acknowledged that environmental regulation governing hydraulic fracturing for shale gas will increase. Some jurisdictions have already introduced a moratorium on production, as summarized in a recent report from the Council of Canadian Academies (CCA, 2014). Governments in both Canada and the United States have passed legislation to improve and harmonize regulations on the fuel economy of both light vehicles and heavy trucks (Environment Canada, 2013).

These examples reflect a growing concern for environmental issues related to energy that range from the impact of greenhouse gas emissions on the global climate to the more localized concerns about the effect of hydraulic fracturing on nearby water supplies. As well, there is heightened awareness of both environmental and safety implications of transporting energy, as demonstrated by the public reaction to recent pipeline spills and train derailments.

It is difficult to know how these concerns will play out, but they suggest higher costs for all energy, and disproportionately higher costs for fossil fuels. How firms address these issues and how society copes with environmental and social challenges from developing current energy reserves are outside of the scope of the Panel's mandate. Nevertheless, the Panel was convinced that these are important factors to be considered when looking at the future of energy.

Costs of not addressing environmental problems could well spill over to other firms and the wider population beyond those industries directly exposed. A greater risk of low-probability, high-impact catastrophes would create significant infrastructure damage whose reconstruction would need to be financed by insurance firms and/or government, as well as disrupt all manner of business (Weitzman, 2009).

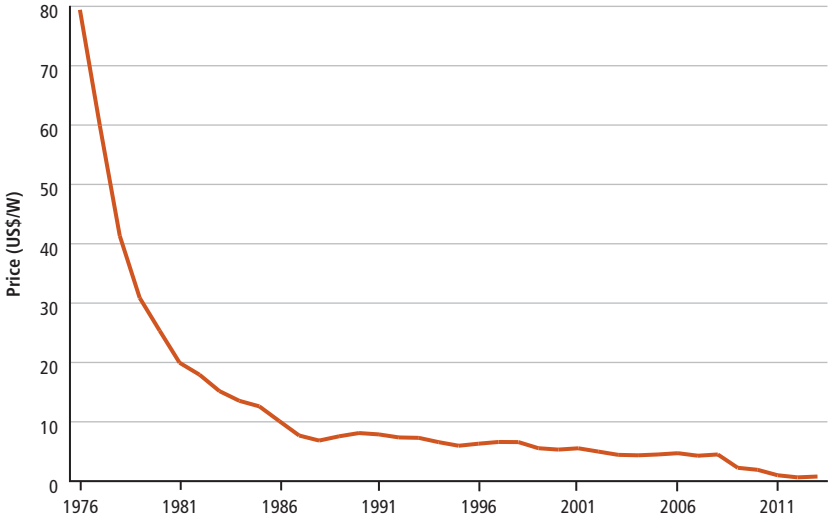
Growing public concern about the environment around the world means that business decisions made in Canada will have to take global perceptions into account. A recent example shows how decisions on exploiting energy sources in Canada rely on political decisions taken in the United States and how those decisions rely, in turn, on the public's view in the United States of Canada's environmental stewardship. Indeed, environmental concern can rapidly crystallize into decisive shifts in policies, such as the influence that the Cuyahoga River in Ohio catching fire in 1969 had on spurring "an avalanche of pollution control activities resulting in the Clean Water Act, Great Lakes Water Quality Agreement and the creation of the federal and state Environmental Protection Agencies" (EPA, 2013). Such rapid change is even more likely in a world where social media can readily mobilize action on environmental problems.

Global change on energy policy could have profound implications for Canada since it is a major energy producer and tends to attract businesses that are energy intensive. Although Canada has many advantages in terms of clean power from hydroelectric to biofuel capacity, a global movement away from fossil fuels would have an impact on firms tied to exporting such fuels. Such a global move may not even be policy driven, as technological change could lessen the need for material and energy inputs.

2.5.6 Technological Advances

Technological advances could help firms reduce how much energy they need to produce a given level of output, particularly as real prices are expected to rise (Hassler *et al.*, 2012). As research into technology and practical development in the field help improve operations, the cost of equipment declines, leading to wider adoption of new technologies (Chakravorty *et al.*, 1997).

Figure 2.13 shows how the per unit cost of silicon technology that enables solar-powered electricity has declined over the past few decades (see also Borenstein, 2012). Since renewable power tends to rely more on fundamental technology change, research and development (R&D) and widespread adoption have the potential to lower costs further. The ultimate extent of the switch to renewable sources may, therefore, be underestimated in the EIA (2013a) reference case, although, as noted earlier, reliability issues associated with the large-scale integration of renewable energy sources into the bulk power system will have to be addressed.



Data Source: Bloomberg New Energy Finance and Paul Maycock (personal communication)

Figure 2.13

Decline in the Cost of Solar Energy

The figure shows the decline in the price of crystalline silicon photovoltaic cells in constant dollar terms. Technological advances and scale economies have lowered the per-unit cost over time.

The incentive to invest in economizing on energy increases with the price of energy. Alternatively, if there were lower prices of energy — as generally predicted for natural gas — then technologies that make more intensive use of it will be encouraged. Over the medium term, the pace of electrification is likely to increase as it is a more flexible source of energy, particularly if there are breakthroughs in technologies to store electricity.

The pace of technology can surprise, however. The take-up of horizontal drilling in extracting shale gas accelerated rapidly within the space of a few years. On the consumer side, hybrid cars are rapidly being accepted (Turrentine & Kurani, 2007). These technological changes as well as uncertainty about the future evolution of energy prices make medium-term decisions on energy challenging for firms.

2.6 CONCLUSION

This chapter has explored Canadian and global energy prices, highlighting both past and current energy prices and factors that may influence price trends in the future. Whether for use as a source of energy or as a feedstock, the price of natural gas is now significantly lower than the (energy-equivalent) price of oil, and is expected to remain so for some time. As a result, there is no single energy price because the prices for different sources of energy have decoupled, particularly in North America. Electricity prices are generally influenced by government policy in most provinces, and therefore may not closely track prices in traded energy sources. In considering how energy prices may evolve in the future, increasing concerns about the environment and safety, reflected in enhanced regulations, will put upward pressure on the prices of fossil fuels. Taken together, these phenomena underscore the growing complexity of the energy world, where drivers and impacts of business decision-making reflect more than just energy prices. This complexity will become even more apparent in Canada as the United States further develops its domestic reserves of oil and gas, lessening the need for Canadian imports. The resilience of Canadian firms will be tested in coming years.

3

Firm Decision-Making in the Energy Context

- The Economics of Firm Decision-Making in the Energy Context
- Management Decisions in the Context of Changing Energy Prices
- Examining the Impact of Higher Energy Prices: Sectoral Exposure in Canada
- Conclusion

3 Firm Decision-Making in the Energy Context

Key Findings

- Firms in sectors that use energy and capital intensively in their production processes are exposed to energy prices. These firms face strong incentives to respond to energy price changes by reducing energy use through investing in energy-efficient machinery and equipment, adopting new business processes, switching fuel sources, or hedging with financial instruments.
- Firms that produce energy-consuming products are also exposed to energy prices. As energy prices rise, these firms have incentives to improve the energy efficiency of their products whether sold to consumers or to other firms.
- In reaching decisions on how to best react to changing energy prices, managers are confronted by real-world problems of uncertainty and a lack of information. These are particularly important for energy-related decisions, as investment in equipment is long lived and irreversible. Such information problems may prevent managers from making appropriate decisions on energy use, leading to underinvestment in energy-efficient equipment and technology.
- Research suggests that management strategies and practices, information availability, and staff energy literacy and responsibilities together influence business decisions on energy matters.
- Firm decision-making on energy is best approached through a sectoral analysis since changing energy prices affect some sectors more than others. The eight sectors exposed to energy prices are: the energy-intensive resource-based, manufacturing, and transportation services sectors; the capital-intensive oil and gas, mining, electric power, and other sectors; and the transport equipment manufacturing sector.

Before turning to an analysis of energy use and performance by sector in Canada, it is important to understand more about how firms make decisions. This chapter explores the decisions firms would be expected to make in theory in response to changes in energy prices. It begins by reviewing the economics literature on firm decision-making, distinguishing firms according to their relationship with energy (i.e., firms in sectors that use energy or capital intensively in their production processes and firms that produce energy-consuming products). The literature also highlights potential challenges for managers when the trajectory of energy prices is uncertain, and when they do not have complete information on, for example, the best type of equipment in which to invest.

Managers, however, have to address the challenges suggested by the research literature in the real world. Consequently, the chapter reviews the management literature to obtain a more fine-grained understanding of practical decision-making by managers. Combining the insights from both literatures provides a high-level overview of factors that can potentially influence firm energy decisions.

The management strategies available to address energy price challenges are more likely to be put into practice in those sectors that are exposed to energy prices (recall the Panel's interpretation of *exposed* in Section 1.2.). Hence, the Panel drew on the empirical evidence to identify these exposed sectors in Canada, which provide the focus for its further analysis of business decision-making in the rest of the report.

3.1 THE ECONOMICS OF FIRM DECISION-MAKING IN THE ENERGY CONTEXT

3.1.1 Energy as a Factor in Production

As the price of energy rises relative to other inputs, aggregate energy intensity generally declines.[10] This decline comes from several adjustments. First, for firms in industries that use energy intensively in their production processes (e.g., chemical manufacturing, paper manufacturing) or that use capital goods intensively (e.g., oil and gas extraction, mining), there is an incentive to decrease energy use. Second, for firms that produce energy-consuming products (e.g., automobiles, aircraft, appliances), higher energy prices reduce demand for their products, encouraging them to improve the energy efficiency of the goods and services they sell. Finally, there are important reallocation effects across the economy as investment and workers move away from less energy-efficient producers.

Increases in energy prices can lead to reductions in energy use in several ways. In the short run, an increase in energy prices can result in energy conservation, by adjusting existing equipment and production processes, decreasing production levels, or implementing specific management practices (see Section 3.2). In this context, energy conservation results in lower energy use if it is not accompanied

10 If other factors change (for example, if workers and investment move towards extracting energy), energy intensity may increase as energy prices rise. This has occurred since 2003 in Alberta and Saskatchewan.

by energy efficiency improvements.[11] As such, these strategies generally have limited scope outside of the short run. If an increase in energy price is persistent, however, firms have an incentive to investigate achieving energy efficiency gains. This can be accomplished with three strategies: investing in energy-efficient capital, developing and adopting new energy-efficient products and processes, and switching fuel sources (Popp *et al.*, 2010). Firms can also use financial instruments as a fourth strategy to manage the risks associated with rising energy prices.

Investing in Energy-Efficient Machinery and Equipment

The decision to invest in energy-efficient capital involves trading off the initial capital cost against savings in future energy operating costs. Determining the future savings requires forming expectations of uncertain future energy prices, desired production levels and equipment utilization, changes in other operating costs (e.g., government regulations), and the decision time horizon (Gillingham *et al.*, 2009).

Investment in energy-efficient products is generally termed "irreversible." Hence, for example, insulation installed during a period of high energy prices is not removed when prices subsequently drop. The irreversibility of equipment purchases means that uncertainty has an important effect on investment decisions because a firm cannot easily undo the investment if the energy price change is reversed (Bernanke, 1983; Dixit & Pindyck, 1994). Consequently, firms will only respond to changes in energy prices that they perceive to be permanent, and are less likely to respond to transitory effects (Elder & Serletis, 2010). Although prices may have started to rise around 2001, firms may not have understood the structural change in global energy markets and realized that the change was permanent. Volatility in energy prices makes it difficult to disentangle permanent shocks from transitory ones because it is

11 In this context, *energy efficiency* is typically defined as the energy services provided or physical goods produced per unit of energy input (Gillingham *et al.*, 2009). For example, the energy efficiency of an industrial cooling system is the amount of heat removed from air per kilowatt-hour (kWh) of electricity input; however, for an industrial production system energy efficiency is the amount (tonnes) of product (e.g., cement, paper) produced per unit of energy. Technically, *energy intensity* is the inverse of efficiency (i.e., energy used per unit service or product), but this is not the case if the service or product is influenced by other factors (e.g., industry structure shifts to less intense products). In contrast, *energy conservation* is typically defined as a reduction in the total amount of energy consumed after undertaking a "conservation action." As such, energy conservation may or may not be associated with increased energy efficiency or reduced energy intensity, depending on how demand for energy services changes (Gillingham *et al.*, 2009). The latter effect is often referred to as the "rebound effect" (Greening *et al.*, 2000) or the "Jevons Paradox" (Jevons, 1866).

difficult to extract a clear signal (Kilian, 2008). This challenge is playing itself out currently as firms try to assess the long-term impacts of increased supply of natural gas leading to a lower price.

Determining whether a price change is a temporary phenomenon or permanent is a challenge for firms. Hence they may ignore it if they think it is temporary or they may delay investment to wait for further information.[12] Box 3.1 explains how some firms have responded to this challenge by applying fuel surcharges.

Box 3.1
Fuel Surcharges

Volatility can adversely affect firms in the short run. Firms take a risk when they set prices for their products because of the time lag between when they sign a contract and when they pay for the fuel used in fulfilling that contract. If fuel costs were to rise unexpectedly, the additional cost would hurt profits directly. Many strategies have been adopted by firms to control this risk, including the use of financial instruments to hedge against higher energy prices.

Another common tactic that many firms use is to apply a fuel surcharge on top of the base price of their product. Consequently, after the price of the product is established, any unanticipated changes in fuel prices are reflected in this separate fee. Effectively, the fuel surcharge shares the risk of volatile energy prices between a firm and its customers. Publishing schedules of surcharges in advance ensures that firms do not take advantage of episodes of volatility to pass on more than their fair share of energy price increases, and that indeed surcharges fall back as fuel prices fall. However, such transparency has been called into question, as airlines have renamed fuel surcharges as taxes, a practice currently being challenged under British Columbia's consumer protection laws (SCBC, 2012).

A degree of risk remains for firms using fuel surcharges because surcharges are typically adjusted irregularly. For example, Canada Post changes its surcharge every month, and charges a higher rate for express delivery, while Purolator sets its rates every week. Fuel surcharges have been introduced on many services that use fuel intensively, particularly those provided by rail, ferry, airline, trucking, waste removal, and logistics firms.

12 There can be benefits to early investment in equipment despite uncertainty about prices (Miller & Côté, 2012). For example, significant investments have been made in LNG infrastructure in the United States to take advantage of lower prices.

Taken together, investment irreversibility and price uncertainty often render energy-efficient investments less attractive than other capital investments. As Lawrence Summers (2009) remarks: "If energy prices will trend higher, you invest one way; if energy prices will be lower, you invest a different way. But if you don't know what prices will do, often you do not invest at all." Ultimately, in the absence of barriers (see Section 3.1.3), sluggish investment in energy-efficient capital is to be expected.

Adopting Energy-Efficient Business Processes

Firms may also develop and adopt new energy-efficient processes to change their production possibilities or production costs (CCA, 2009, 2013b). The role of technology change in the production process has received considerable attention in the academic literature (Popp *et al.*, 2010). The so-called "induced innovation" hypothesis (Newell *et al.*, 1999; Hicks, 1932) posits that increasing energy prices drive technological change that supports the adoption of less energy-intensive capital goods and/or production processes. Indeed, data in the United States show a substantial degree of responsiveness of technology development and adoption to energy prices (Newell *et al.*, 1999; Popp, 2002, 2006; Gillingham *et al.*, 2009).

The Panel, however, is not aware of any empirical evidence of this effect on Canadian firms. More generally, it has been demonstrated and argued elsewhere (CCA, 2009, 2013c; Miller & Côté, 2012; OECD, 2012) that Canadian firms are less innovative than their OECD counterparts owing to a confluence of factors (e.g., economic structure and competitive intensity, public policies, and business culture). Although investment in energy technologies may enable firms to cope with higher prices initially, options diminish over time if the pace of technological change in such equipment does not accelerate.

Switching Fuel Sources

If the prices of different types of energy diverge, some firms can substitute between energy sources to cut costs. Three key factors govern fuel switching potential. First, from a technological standpoint, only some production process and types of capital equipment can use different fuel sources. Second, transaction costs (e.g., transportation, storage, trade costs) and differences in fuel characteristics (e.g., energy content) influence the degree of substitutability between fuel sources.[13] Third, sunk capital investment may prevent switching because it may not be technologically (Steinbuks, 2012) or financially feasible

13 Several studies have attempted to estimate elasticities of substitution for different fuels. The size of estimated elasticities varies significantly. Different data and econometric methods render these results difficult to reconcile.

(Jacoby & Sue Wing, 1999). Combined with organizational barriers to technology adoption and information asymmetries, this may result in an energy technology lock-in (Unruh, 2000, 2002), which lowers the degree of fuel switching.

Using Financial Instruments

These three strategies — investing in energy-efficient capital, developing and adopting new energy-efficient products and processes, and switching fuel sources — all reduce energy use. Firms can also use a set of financial instruments to manage the financial risk of energy prices themselves. These instruments can be used to lock in future prices or minimize the risk of large fluctuations in prices as part of an overall hedging strategy (Kaminski, 2004; Clewlow & Strickland, 2000). Derivatives, for example, are contracts in which the underlying asset is an energy product (such as oil, natural gas, or electricity), and its value determined by expectations of changes in energy prices. These derivatives may take several forms including forwards, futures, options, and swaps.

3.1.2 Energy Prices as a Factor in Consumer Purchases

As noted above, rising energy prices may induce firms to produce products that consume less energy. Firms that produce highly energy-consuming products, like vehicles or appliances, face consumer demand that is a function of the energy use requirement of their product. It follows that the more responsive demand for the product is to changes in the price of energy (i.e., the greater the demand elasticity), the greater is the incentive for firms to produce more energy-efficient products.

Using 1958–1993 data from the United States, Newell *et al.* (1999) explore this hypothesis for three goods: room air conditioners, central air conditioners, and gas water heaters. Estimating an econometric model of the induced innovation and energy intensity for these three goods, they found significant increases in energy efficiency induced by energy price changes. In the first part of the period (pre-1970), product innovation was biased away from energy efficiency as (real) energy prices were falling. In the second part of the period (post-1970), product innovation significantly increased energy efficiency, with more efficient products supplanting less efficient products, as the result of two major energy price shocks. Taken together, these results support the notion that rising (falling) energy prices lead to the production of more (less) energy-efficient products. In fact, this price-induced "model substitution" effect accounted for between one-quarter and one-half of the total observed improvements in mean energy efficiency between 1958 and 1993.

In general, both consumer demand elasticity (i.e., the availability of substitutes) and discount rates[14] (i.e., the rate at which a consumer values current over future consumption) determine the development and price of energy-efficient products. On the one hand, recent evidence from the United States suggests that consumer demand for energy-efficient products, both over the short and long run, is not overly responsive to energy price changes (i.e., it is price inelastic). Examples of such products include automobiles (Knittel, 2012; Jacobsen, 2013; Klier & Linn, 2010); lighting (Allcott, 2011); and appliances (Eichholtz *et al.*, 2010). Similarly, empirical estimates of discount rates point to a rather high degree of impatience among consumers (Hausman, 1979; Sanstad *et al.*, 2006). On the other hand, energy efficiency seems to be much higher in European countries where energy prices are much higher (OECD/IEA, 2007).

Reconciling these findings is complicated by: individual factors (e.g., information, liquidity constraints); marketing efforts that influence consumer decision-making (Gillingham *et al.*, 2009; Allcott & Mullainathan, 2010); social and cultural influences; and economic and policy differences. These findings may very well imply that the link between energy prices and the production of energy-efficient products is not strongly driven by consumer demand; however, they may also reflect lower energy prices in North America or a host of other factors. More research could be conducted to tease apart these relative influences on the relationship between energy prices and consumer purchases.

3.1.3 Barriers to Firms' Energy Efficiency Decision-Making

The economics literature discussed earlier highlights barriers that constrain decision-making. In general, this leads to underinvestment in energy-efficient equipment and technology by firms.

Information plays an important role in decision-making. On the one hand, firms may lack sufficient information on energy prices or on the difference in future operating costs necessary for the investment decisions described earlier (Gillingham *et al.*, 2009). Asymmetric information, on the other hand, can lead to the following:

- Quality uncertainty – Producers of energy-efficient technologies may be challenged in convincing customers that their equipment provides clear *ex post* benefits to firms. Producers have an incentive to claim that the energy efficiency of a product is high while purchasing firms may ignore this information when they cannot *ex ante* observe energy efficiency. As such, firms underinvest in energy technology.

14 Consumer discount rates are "implied" in that they are inferred from consumer purchases of products with different prices and different levels of energy efficiency.

- Principal-agent problem – When the principal has less information than the agent about energy efficiency, the agent may not be able to recover the costs of energy-efficient investment (Gillingham *et al.*, 2009). The classic example is that of a building owner who determines the energy efficiency of a building when selecting heating and cooling systems while the tenant pays for the energy used. The tenant may benefit from better systems, but the building owner may not be able to recover the costs of the energy-efficient investment. As such, there will be underinvestment in energy efficiency (Jaffe & Stavins, 1994; OECD/IEA, 2007).

In practice, firms face many obstacles to investing in energy efficiency. For example, some firms may not invest in energy-efficient capital because they lack access to credit. The extent to which these liquidity constraints factor into firm decision-making has yet to be established empirically. Firm-specific barriers to higher energy efficiency include organizational and management structure (DeCanio, 1998); cognitive limitations and deviations from rationality on the part of energy management (Shogren & Taylor, 2008); and other firm-specific characteristics (DeCanio & Watkins, 1998).

In principle, these barriers could create an energy efficiency gap — the "difference between observed levels of energy efficiency and some notion of optimal energy use" (Allcott & Greenstone, 2012). The existence and magnitude of these barriers are, however, an empirical question. At present, there are insufficient data to understand their potential relative impacts on Canadian firms.

3.2 MANAGEMENT DECISIONS IN THE CONTEXT OF CHANGING ENERGY PRICES

The previous section explored firm decision-making according to standard economic theory. While this approach is certainly useful to understand how energy prices can influence firm production processes and product mix, it does not describe how decisions are actually made. The management literature helps in this regard.

3.2.1 Integrating Levels of Management on Energy Decisions

A standard approach in the management literature suggests that there are three levels of decision-making within organizations: strategic, tactical, and operational (Montana & Charnos, 2008; Bunse *et al.*, 2010; Burstein *et al.*, 2011). The strategic

level considers how firms position themselves and their products within their competitive environment. Strategic decisions include product mix, marketing efforts, and financial targets. The strategic level is especially important as it affects overall corporate culture and a firm's ability to be flexible to changing circumstances. The tactical level of decision-making focuses on how to implement practices to achieve the objectives and targets of strategic decision-making. For instance, decisions at this level consider what equipment is required for production, what design characteristics are required to support product strategies, and what technology is needed to determine energy efficiency. The third level, the operational level, considers day-to-day production requirements, equipment maintenance, and energy-use monitoring.

These three levels of decision-making influence each other. Energy-efficient measures at both the tactical and operational levels require long-term planning at the strategic level, and the success of a long-term strategic energy plan requires successful implementation and buy-in at the lower levels of decision-making. McKane *et al.* (2007) stress that successful implementation of an energy management plan requires involvement of personnel throughout the organization. For instance, even if staff at the operational level are "trained in both skills and general approaches to energy efficiency" for day-to-day practices, the impact will languish if performance results are not regularly evaluated at the tactical level and communicated to the strategic level (McKane *et al.*, 2007).

The interaction across management levels varies with the type of decision. Some decisions affect the supply of energy to a firm — through pricing agreements or self-generation of electricity — while other decisions involve changing the firm's demand for energy, whether the quantity of energy consumed or the time of day it is used (Thollander & Ottosson, 2010). Operational-level measures such as heating, lighting, and ventilation are typically less capital intensive than the production process investments, and require less oversight from higher levels of management (Thollander & Ottosson, 2010). By contrast, capital-intensive production investments require more guidance from the strategic decision-making level. Box 3.2 considers how energy prices influence decisions on buying and operating airliners across manufacturers and purchasers. The discussion highlights how decision-making is dispersed across a market.

Box 3.2
Energy Strategy in the Aircraft and Airline Industry

The high cost of oil means that fuel is generally about 30% of a given airline's total operating costs (Lawrence, 2009; Airbus, 2013a), with the International Air Transport Association projecting this share to rise to 33% in 2014 (IATA, 2013). To cope, airlines have raised their load factors for both freight and passengers above pre-2008 recession levels (Pearce, 2012), and between 1980 and 2011 they improved annual fuel efficiency by about 2.3% (Airbus, 2013a). In addition, many airlines have included fuel surcharges in ticket prices, thereby passing on some of the costs to travellers.

On the technology side, advances in aerodynamics, control systems, engine technology, and materials have enabled aircraft manufacturers to produce more fuel-efficient airplanes, with new generation large aircraft about 20% more efficient than their predecessors (Lawrence, 2009; Airbus, 2013b, Szodruch *et al.*, 2011). Lee (2010), however, claims that tactical and operational changes have been the main driver of aircraft energy efficiency improvements. In particular, 57% of the reductions in energy intensity from 1959 to 1995 were from improvements in engine efficiency, and 22% from increases in aerodynamic efficiency. The oil shocks also prompted better use of existing resources, and higher load factors of airplanes (Schipper *et al.*, 1990; Lee, 2010). Newer, more fuel-efficient airplanes are being used on the higher-frequency routes, meaning less chance of passenger disruption due to airplane repairs and greater operating efficiency for the airline.

The management decisions made by two large aircraft manufacturers, Boeing (United States) and Airbus (France), illustrate different approaches in dealing with the higher fuel prices. Airbus believes that higher fuel prices will continue, and is developing "alternative fuels" such as biofuels for commercial flights (Airbus, 2013c). In contrast, Boeing believes that increased supply from shale oil production will help moderate prices, and anticipates "a modest increase in the average size of airplanes in operation," which will help airlines to minimize their fuel costs (Boeing, 2013).

The benefits of within-firm management integration can pay significant dividends. There is often a misalignment of incentives across the three levels of management. For instance, there are sometimes budgetary disconnects in industrial facility management between capital projects and operating expenses (McKane *et al.*, 2007). Box 3.3 examines how the separation of decision-making between different individuals with separate responsibilities has influenced energy consumption across the Swedish pulp and paper industry.

Box 3.3
Energy Strategy in the Swedish Pulp and Paper Industry

In 2005, Sweden was the third largest exporter of paper products and the fourth largest exporter of pulp in the world (SFI, 2011). The industry consisted of 60 mills, employed 27,500 individuals, and accounted for roughly 6% of GDP. Between 2000 and 2006, electricity prices almost doubled and oil prices rose by around 70% (SFI, 2011). The Swedish pulp and paper industry is a considerable user of energy, accounting for approximately 50% of Swedish industrial energy use and 2% of EU-25 industrial energy use (Eurostat, 2007).

To mitigate the threat of rising energy prices, the industry has increased its use of electricity and biomass while decreasing its use of fossil fuels since the 1970s (Eurostat, 2007; SFI, 2011). In addition, pulp and paper firms have become increasingly energy efficient by varying production in response to energy price changes, and developing and adopting leading-edge pulp production technologies (Thollander & Ottosson, 2008; Wising *et al.*, 2005).

The Swedish Long-Term Agreement program for energy efficiency for energy-intensive industries, launched by the Swedish Energy Agency in 2005, involves some 100 firms including the majority of Swedish pulp and paper firms (Ottosson & Petersson, 2007). This program provides firms with tax exemptions for electricity use provided that they implement standardized energy management systems, clean production techniques, and infrastructure retrofits. Although the industry relies heavily on biomass and fossil fuels, this policy has been effective in promoting energy efficiency investments.

Nonetheless, a significant "energy efficiency gap" exists (SFI, 2011). Several factors potentially drive the energy efficiency gap: cost of sub-optimal production, inappropriate technology, time, capital constraints, and managerial skills (Thollander & Ottosson, 2008; Johansson *et al.*, 2007; Rohdin *et al.*, 2007). In addition, many Swedish mills split the responsibility of production and energy use management among different departments. This results in a principal-agent problem: production managers lack sufficient incentives to effectively control energy costs and implement energy-saving production technologies (OECD/IEA, 2007).

A 2009 survey of Swedish mills highlighted that energy conservation and efficiency had been given increasingly higher priority by management during the preceding decade (Thollander & Ottosson, 2009). While promising, the results demonstrate that there is room for improving management practices.

3.2.2 Performance Indicators

A key challenge for many firms is a lack of accurate and flexible performance indicators and benchmarks. The lack of comparable data limits the operation and tactical responses of firms in developing energy efficiency measures. In fact, even when this information is available many firms fail to use it (Bunse *et al.*, 2011). Thollander and Ottoson (2010) point out a lack of sub-metering of energy use in Swedish energy-intensive industries, arguing it is because energy management is not a priority. They also suggest that even when energy use is monitored, the costs are not necessarily allocated to the corresponding departments, which could reduce the incentive for middle management to focus on saving energy. Box 3.4 provides an example of how the use of performance indicators has led to successful energy management at Alcoa Pinjarra, an Australian alumina refining firm.

Box 3.4
Energy Strategy of Alcoa Pinjarra

Alcoa World Alumina Australia — a partnership between Alcoa Inc. and Alumina Ltd. — is Australia's largest producer of alumina (aluminium oxide), a key starting material for the smelting of aluminium. The Alcoa refinery at Pinjarra in Western Australia accounts for one-fifth of total Australian production (IAI, 2013; Australian Government, 2012). The extraction of alumina from bauxite is a highly energy-intensive process, accounting for approximately 20% of operating costs. Annually, the refinery consumes 38 petajoules (PJ) of natural gas, over four million kWh of electricity, and smaller amounts of oil (Alcoa, 2013). Energy intensity improved by 5% between 2001 and 2007 at the Pinjarra refinery resulting from a condensed heat recovery upgrade of the refinery and construction of two cogeneration plants that "use waste heat from power production to simultaneously generate power and steam for the refinery" (Australian Government, 2012). The cogeneration plants have reduced energy consumption at Pinjarra by approximately 0.52 gigajoules/tonne (GJ/t) of production, saving approximately A$7.5 million per year (Australian Government, 2012). As a result, annual export revenue increased by A$160 million because of increased alumina yields.

continued on next page

In 2012, Alcoa adopted an energy management system that includes daily energy monitoring, weekly reporting, and monthly benchmarking, involving all plant management personnel (Alcoa, 2013). These results are prominently displayed on several energy use whiteboards throughout the refinery. Alcoa's energy management system is supported by "comprehensive data collection and analysis" (Alcoa, 2013). Overall energy efficiency — measured by energy intensity (GJ/t of alumina) — is benchmarked relative to annual targets and international benchmarks (Alcoa, 2013). Data are collected and analyzed for all major processes (Alcoa, 2013), which enables energy impacts to be measured at the refinery level (Australian Government, 2012). Plant managers also focus on indicators that provide "early warning of efficiency problems, such as steam usage, boiler efficiency, evaporation efficiency, yield and power generation efficiency, as well as key indicators such as energy consumption" (Australian Government, 2012). Energy efficiency considerations are highlighted in monthly management meetings and quarterly board meetings (Alcoa, 2013).

Some Canadian firms have been successful in energy monitoring. For example, in 2005 General Motors of Canada received the Canadian Industry Program for Energy Conservation's Industrial Energy Innovator Award for implementing an energy monitoring, tracking, and reporting system. The system was installed in its Oshawa, St. Catharines, and Windsor plants, which, as a result, reduced their energy use by 6.2% between 2003 and 2004 (Energent, 2013).

3.2.3 Energy Literacy and Sources of Energy Information

Energy literacy is defined in a University of Calgary study as a term to describe consumer values and knowledge regarding the energy system that supports daily activities including those at home, in commerce, and in industry (Moore *et al.*, 2013). The study assesses the energy literacy of business and policy decision-makers across Canada by surveying them about their attitude towards energy, investment in energy, energy practices, and energy demand. It appraises energy knowledge based on what individuals think they know and on their actual level of knowledge. The study concludes that Canadian leaders are not more knowledgeable about Canadian energy systems than the general public. For example, some respondents from Ontario, Alberta, Saskatchewan, and the Atlantic region were unable to correctly identify the primary source of energy in their province. However, leaders' views are often given more weight because they influence the way the public thinks about energy and they can affect policy decisions.

The leaders surveyed indicated that their concern for energy was secondary to the economy, jobs, and health care, and they tended not to view energy as independent, but as integrated into other sectors of the economy. However, when asked specifically about the importance of energy, between 71 and 90% of respondents (varying by province) ranked energy as either a "very important" or "somewhat important" concern.

The study also focuses on leaders' main sources of information about energy issues. Respondents mostly indicated that they were satisfied (62%) with the information currently available. In terms of energy information, respondents identified television, internet, national newspapers, and government reports as the main sources of information (in order of prevalence) they turn to for energy matters. They indicated that there were gaps in information about costs/prices, effects on research and future development, conservation, and alternative energy sources. Respondents were sceptical about information from energy firms, industry groups, and government officials, identifying economic experts and academics as a better source. They also indicated a need for more non-biased, fact-based information, as well as improved energy planning, education, and involvement for society as a whole (Moore *et al.*, 2013).

3.2.4 Research on Management Practices

Over the last few years, economists have started to explore the importance of various management practices in determining the performance of individual firms. Bloom and Van Reenen (2007) have developed new methodologies[15] to overcome concerns that respondents to a given survey are not completely objective in their responses (Bertrand & Mullainathan, 2001). The literature spawned by this research highlights the importance of benchmarking and performance tracking in business performance.[16]

15 Their methodology overcomes concerns about surveys through a "double blind" methodology of interviewing managers. First, managers being interviewed were not made aware that they were being graded (or on what). The interview was unstructured to try to elicit information without asking for it directly. Questions were asked about management practices, and then these practices were scored. Second, the interviewers were not aware of the identity or financial performance of the firms, reinforced by choosing to interview managers of mid-sized firms. Data from the management interviews were then married with detailed data from statistical agencies on those firms' financial performance. Firms were scored on 18 practices, related to operations, monitoring, targets, and incentives. For example, the practices evaluated for operations related to introduction of lean manufacturing techniques, documentation of process improvements, and the rationale behind introductions of improvements. Grades were assigned from one to five based on objective criteria. In the original research, better scores on management practice were found to be associated with better firm productivity, profitability, and survival rates.

16 The importance of benchmarking specifically in improving firm-level productivity was also found in earlier analysis of U.K. firms by Black and Lynch (2001).

The Bloom and Van Reenen methodology has been extended to many areas, and a small group of papers is relevant to the Panel's charge. Bloom *et al.* (2010) examine links between management practices and energy intensity. Better managed firms are less energy and material intensive, irrespective of industry, location, size, and other factors. To put the scale of impacts into perspective, improving management practices from the bottom to the top quartile would lower energy intensity by 17.4%. Improving management practices from U.K. to U.S. levels would reduce energy use by 7.5%.

Bloom *et al.* (2010) also explore possible key components of management practices. Better operating practices through "lean manufacturing" explicitly aim to lower the amount of energy or other materials used. However, another possibility is that better management would "enable firms to generate and implement a broad [range] of energy-saving ideas." As mentioned in Section 3.1.3, information or principal-agent problems may inhibit firms from investing in energy efficiency, but these barriers may be less important in better managed firms. Better monitoring would mean energy-saving ideas are picked up, appropriate targets could lead to focus on a wide range of goals, and employees could be encouraged to think about energy-saving ideas outside of their own department. In evaluating the impact of each management practice separately, the researchers found that all elements play some role in lowering energy use. However, they also found that use of performance indicators in production and people management together play a larger role. So, although tentative, the authors believe that lean manufacturing on its own is not sufficient to lower energy intensity, but needs to be combined with some sort of consequence management.

Martin *et al.* (2012) dig deeper into the impact of firm organization on energy use. U.K. respondents to their study suggested, for example, that the timeline for payback criteria for energy efficiency improvements seems quite short, and that there is a general bias against energy efficiency projects. Their data show a strong positive relationship between productivity and an energy targets index measuring the monitoring of energy use, the presence and stringency of targets, and their enforcement. The authors conclude that "differences in energy efficiency across firms within a given sector are driven by measurable difference in management practices rather than by various climate policies that have been implemented in the U.K."

Turning to the organization of firms, Martin *et al.* (2012) asked: (i) "Is anybody responsible for dealing with climate change policies and energy and pollution reduction in the firm?", and (ii) "How far in the hierarchy is this manager below the CEO?" They found that firms in which the climate change, the environment or the energy manager manages issues were more likely to adopt

climate-friendly management practices. Climate-friendly policies were also more likely to be adopted the closer the manager was to the chief executive (unless the energy manager was the chief executive in which case they were less likely to be adopted). These results suggest that there are information or principal-agent problems in making decisions on energy.

The research suggests that better management practices are associated with lower energy intensity. An apparent paradox that emerges is that firms based in the United States are generally found to be better managed, but also more energy intensive, than firms in Europe. Martin (2010) explores this issue. The higher energy intensity in North America could be explained by the lower price of energy in the United States (as in Canada) than in Europe. However, the magnitude of energy intensity differences is too large to be explained by price differences, bearing in mind the low responsiveness of firms to price differences (i.e., that energy is price inelastic). Another factor such as climate could also play a role. Because the confluence of potential causal factors is difficult to disentangle in comparing firms, Martin (2010) examines the performance of U.S.-based firms operating in the United Kingdom. He finds that U.S. firms that have been in the United Kingdom for a while are as energy efficient as their U.K. counterparts. However, when they initially enter the country, U.S.-based firms are considerably less energy efficient, a difference that only disappears with a lag of around three years in his sample.

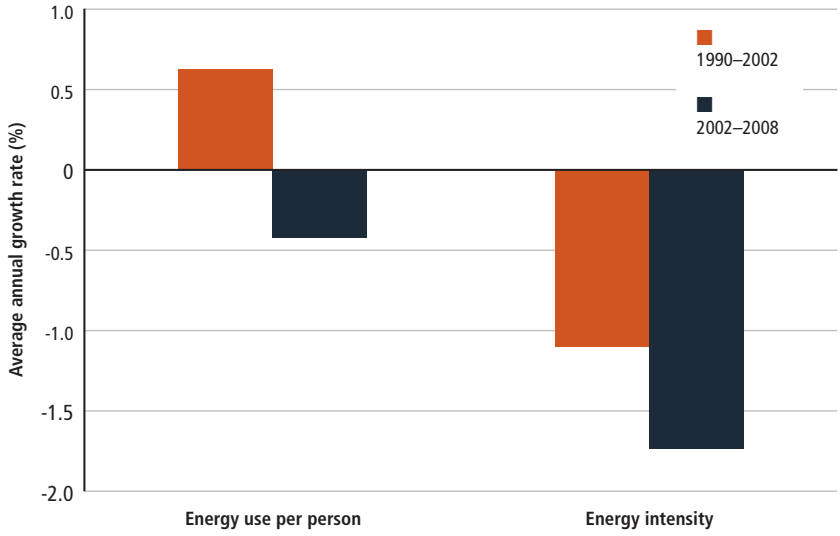
What accounts for this performance? The academic literature on technology diffusion suggests that new technologies do not spread instantaneously across firms because firms may not be aware that the technology exists. Coming into contact with firms that have adopted technology makes them more aware. Furthermore, with the lower price of energy in the United States, firms have less incentive to search for energy-efficient technologies.

Taken together, these findings suggest two conclusions. First, less energy-efficient firms can survive in a market for a long time. This suggests that energy efficiency is not always critical to firms' competitiveness in many areas. Nevertheless, sudden price changes would likely cause disruption. Second, a lack of information available about new technology may limit the degree of adoption. Information about the existence of technology may spread quickly; however, without the appropriate tacit knowledge, potential users will not adopt the technology, even if they are aware of its existence.

3.3 EXAMINING THE IMPACT OF HIGHER ENERGY PRICES: SECTORAL EXPOSURE IN CANADA

As discussed in Chapter 2, higher energy prices over the last decade have had an impact on all Canadian firms, both through rising input costs and by increasing the costs of owning products that use energy intensively. Firms have had an incentive to respond by improving the energy efficiency of their business processes and by supplying goods and services requiring less energy consumption by following some of the strategies laid out in this chapter.

The evidence suggests that these responses have had an impact. Figure 3.1 shows patterns of energy use in Canada in relation to population and size of the economy, both in a period of relatively low and constant energy prices, in the 1990s, and in a period of rising energy prices, between 2002 and 2008. As prices rose, proportionately less energy was used.



Data Source: Panel calculations based on Statistics Canada (2014a, 2014l, 2014m)

Figure 3.1

Changes in Per Person Energy Use and Energy Intensity, Canada, 1990–2008

The figure shows that growth in energy use started to slow, relative to the growth of population and GDP, after energy prices started to rise. *Energy intensity* is energy use per unit of constant-dollar GDP.

The Panel's review of the economics and management literature, and the sectoral patterns that emerged, reinforced its view that firm decision-making on energy is best approached through a sectoral analysis. Consequently, the Panel decided to restrict its choice of sectors for further examination to the sectors that are exposed to, and therefore most affected by, energy prices in the Canadian context. To identify the appropriate sectors, the Panel drew on empirical economics literature, which is mostly based on evidence from the United States.

Davis and Haltiwanger (2001) examined detailed changes in employment patterns by plants across 450 U.S. manufacturing industries in response to an oil price shock. The "cumulative two-year employment response to a positive oil price shock rose sharply with capital intensity and product durability" (Davis & Haltiwanger, 2001).[17] They noted that "apparel, rubber and plastics, furniture, primary metals, and transportation equipment are among the industries with especially large job destruction responses to oil shocks."

Updating and extending this approach, Herrera and Karaki (2013) found that oil price shocks have an impact on gross job reallocation "especially in sectors that are energy intensive in production (e.g., textiles, petroleum and coal, rubber and plastics) or in consumption (e.g., transportation equipment)." Broadly consistent with Davis and Haltiwanger (2001), they found net employment declines in textiles, lumber, furniture, rubber and plastics, stone, clay and glass, and fabricated metals. Exploring the transportation equipment sector in detail, they saw much larger job reallocation in all component industries, but particularly in motor vehicles and passenger car bodies and truck trailers with smaller impacts for parts manufacturing (but large relative to non-auto industries). This last finding links to a further consensus in the economics literature: energy prices have a significant impact on transport equipment manufacturing. Hamilton (2009), for example, argues for the centrality of the automobile sector in explaining the macroeconomic impacts of oil price shocks.

Using data from 1967 to 2009, Ramey and Vine (2010) found fairly similar consumer behaviour in recent years to that experienced 30 years ago. Gasoline price increases caused an increase in anxiety and a shift in demand across vehicle sizes, which resulted in a build-up of inventory and a decline in capacity utilization as manufacturers tried to get rid of their stock. Shifts in demand patterns are "as disruptive to capacity utilization in auto manufacturing plants since 2000 as they were in the 1970s" (Ramey & Vine, 2010).

17 *Energy intensity* is defined as energy costs as a percentage of shipments value; capital intensity is measured as capital per production worker; and, product durability is measured using product-level depreciation rates obtained from an insurance firm.

Bresnahan and Ramey (1993) considered older data and looked at how auto manufacturers have reacted to oil price changes. The process of reallocating production is costly because human capital and complementary physical and managerial capital must be reallocated. Misalignment between capacity and demand produces higher inventory. The oil shock in 1973 meant that capacity utilization was 50% rather than the 60% seen in 1975. However, adjustment can be relatively rapid. The number of plants producing compacts rose from 9 in early 1973 to 16 by the end of 1974. Conversely, the number of plants producing standard-size cars fell from 23 to 14 over the same period. This rapid adjustment was probably facilitated by (i) existing plans to produce a greater number of smaller cars, and (ii) the perception that the oil price change was permanent. Despite these experiences, evidence also suggests that consumers' transportation decisions have become less affected by energy prices. Hughes *et al.* (2008) suggest that short-run price elasticities were almost an order of magnitude lower in 2001–2006 than in 1975–1980.[18]

Based on this evidence, and the availability and aggregation of data available from Statistics Canada, the Panel determined the most appropriate sectors to examine in Canada:

- **Energy-intensive industries that are not capital intensive:** These industries have energy intensity of greater than 5%.[19] Prominent examples at the three-digit NAICS (North American Industry Classification System) level are transportation and warehousing services (excludes pipeline transportation), and agriculture, forestry, fishing, and hunting. A finer disaggregation leads to the inclusion of chemical manufacturing, paper manufacturing, non-metallic minerals product manufacturing, primary metal manufacturing, and repair and maintenance services. This list is broadly similar to the lists produced by Davis and Haltiwanger (2001) and Herrera and Karaki (2013).
- **Capital-intensive industries:** In these industries, capital services are 40% or more of gross output. They include utilities (electric power and gas, and water distribution), mining, oil and gas extraction, pipeline transportation, and waste management.[20]
- **Transport equipment industries:** This group of industries is a special case to be examined separately because the goods it produces consume significant amounts of energy.

18 Specifically, short-run price elasticities ranged from -0.034 to -0.077 in 2001–2006 versus -0.21 to -0.34 in 1975–1980.

19 *Energy intensity* is the ratio of aggregate expenditure on energy to GDP. The 5% threshold was selected after examining a scatter plot of energy intensity by industry.

20 The metric to identify these industries was capital intensity alone, based on the empirical research. However, many of the industries identified turned out to be intimately involved with energy as well, such as electric power and gas, and pipeline transportation.

Collectively, these industries accounted for an average of 27% of the business sector's GDP in 2005–2008.[21] Although they do not form the largest part of the overall economy, the spillover effects of energy prices on all firms can be sizeable. Challenges by these industries in adjusting to energy prices increases can transmit adverse impacts more broadly than their share of the economy suggests.

Table 3.1

Aggregating Canadian Industries to the Sectors of Interest

Sector Defined by Panel	NAICS Industry	NAICS Code
Energy-intensive: resource-based	• Crop and animal production • Forestry and logging • Fishing, hunting, and trapping	111–112 113 114
Energy-intensive: manufacturing	• Paper • Chemical • Non-metallic mineral product • Primary metal	322 325 327 331
Energy-intensive: transportation services	• Air, rail, water and scenic and sightseeing transportation and support activities for transportation • Truck transportation • Transit and ground passenger transportation	481–483, 487–488 484 485
Capital-intensive: oil and gas	• Oil and gas extraction	211
Capital-intensive: mining	• Mining (except oil and gas)	212
Capital-intensive: electric power	• Electric power generation, transmission, and distribution	2211
Capital-intensive: other	• Pipeline transportation • Waste and remediation services	486 562
Transport equipment	• Transportation equipment manufacturing	336
Other manufacturing	• Wood product • Petroleum and coal products • Plastics and rubber products • Fabricated metal product • Machinery • Computer and electronic product	321 324 326 332 333 334
Other services	• Wholesale trade • Retail trade	41 44–45

The table lists the eight sectors in Canada selected by the Panel as exposed to energy prices, followed by two sectors that are less likely to be affected. The component NAICS industries for each sector are also displayed. The "other manufacturing" sector is not discussed in Chapter 4 because it is an extremely heterogeneous sector that does not lend itself to meaningful statistical analysis. It is, however, identified in the survey results in Chapters 5 and 6.

21 Panel calculations based on Statistics Canada (2014k).

The Panel also decided to identify several additional industries that may be less affected by energy prices than those in the three groups above, such as wholesale and retail trade industries and certain manufacturing industries, and use them as a "control" group in its analysis. The Panel's final classification of NAICS industries was reduced to the 10 sectors of interest displayed in Table 3.1.

3.4 CONCLUSION

This chapter has reviewed the theoretical and empirical evidence of firm decision-making in the energy context. Overall, the economics and management literature provides some insight into the relationship between energy prices and firm decision-making. The economics literature highlights factors that govern firm production processes and product mix, and elucidates a variety of possible responses that enable firms to cope with energy price changes and volatility. Strategies may focus on reducing energy use by investing in energy-efficient capital, developing and adopting new energy-efficient products and processes, and switching fuel sources. Firms may also protect against the risk of price changes by using financial instruments. The management literature explores these strategies, highlighting how decisions are made and their influences inside firms. The need for effective management practices, dedicated energy personnel, energy price information, and benchmarking data is becoming increasingly important when making business decisions in the energy context.

The economics literature also suggests that sectoral patterns can be identified in firms' responses to changing energy prices. Therefore, further refining its sectoral approach, the Panel identified the eight sectors in Canada that are exposed to energy prices, and two sectors that are likely less affected to use as controls. The Panel explores the past resilience of these 10 sectors in response to historical changes in energy prices in Chapter 4, and samples firms in these sectors in its business survey (see Chapters 5 and 6).

4

Past Energy Consumption and Industrial Performance in Canada: Sectoral Analysis

- Business Performance in a Period of Rising Energy Prices
- Impacts of Rising Energy Prices on International Competitiveness
- Business Adjustment to Rising Energy Prices
- Business Fuel Use Patterns
- Detailed Sectoral Analysis
- Additional Data Needed to Evaluate Resilience
- Conclusion

4 Past Energy Consumption and Industrial Performance in Canada: Sectoral Analysis

Key Findings

- Data on the level and evolution of energy intensities in both economic and physical terms are central to understanding both the competitive position of sectors relative to other countries, and the response of firms to changes in energy prices.
- The data available suggest that the energy intensities of Canadian sectors are similar to those of comparable sectors in the United States. As such, there are unlikely to be significant adverse competitiveness impacts in terms of lost market share to foreign competitors as a result of higher global energy prices. However, methodological differences between statistical agencies in Canada and the United States hamper comparisons across some industries. A lack of international data prevents direct comparisons with other countries.
- Adjustments made by many Canadian sectors exposed to energy prices to cope with changing energy prices in the past have lowered the quantity of energy used in proportion to output. These adjustments suggest that many sectors have been resilient in the face of higher energy prices.
- The data suggest that some industries have faced challenges as a result of energy price changes, notably paper, chemical, and transportation equipment manufacturing. However, in most cases, changing energy prices were unlikely to be the primary cause of these challenges, but may have exacerbated other cyclical or structural changes. Some of these industries, notably chemical manufacturing, can now take advantage of the low price of natural gas relative to oil.

This chapter evaluates the resilience of Canadian firms by examining how sectors have responded and adapted to the rise in energy prices that began in 2000. In particular, the focus is on the data and historical performance of the 10 sectors selected in Chapter 3: eight sectors that are exposed to energy price changes and two that are less affected by energy prices used as controls.

To evaluate the impact of energy prices on the competitiveness of industries in the 10 sectors, and their resilience in a time of rising prices, the Panel examined energy intensity levels in both economic and physical terms. It also analyzed trends in energy intensity over time using energy intensity growth rates by sector. The expectation for resilient firms or industries is that higher prices result in adjustments so that energy use declines in proportion to output over time. Given the fuels used as sources of energy differ across sectors, the Panel also looked at fuel use patterns.

Although the data suggest that some Canadian industries have faced challenges as a result of energy price changes (e.g., paper, chemical, and transportation equipment manufacturing), the data only provide signals as to how firms have responded. Brief sector profiles in Section 4.5 therefore examine in more detail the experiences of specific industries to determine the role of energy price changes in their adjustments. The sector profiles suggest, for instance, that the paper manufacturing industry faces more fundamental technological challenges. Furthermore, a more nuanced examination of the transport equipment sector suggests that not all its component industries are affected to the same extent when energy prices change.

Data available for the energy-exposed sectors in Canada show that many have reduced their energy intensity over the past decade in response to higher energy prices. An important part of this adjustment process is through the reallocation of resources from less energy-efficient firms to more efficient ones, thus improving overall energy efficiency across the economy (Davis & Haltiwanger, 2001). These inter-firm adjustments are best captured by analysis of sectors, which reinforces the Panel's earlier decision to focus its analysis at the sectoral level rather than the firm level.

4.1 BUSINESS PERFORMANCE IN A PERIOD OF RISING ENERGY PRICES

If energy prices increase, firms can adjust by using one or more of the strategies discussed in Chapter 3. These methods of adjusting to energy prices are critical to maintaining business competitiveness. However, dissecting the data to determine whether Canadian firms have the resilience or capacities to adjust is difficult.

Resilience has not generally been explored by economists. Dhawan and Jeske (2006) suggest that an economy is resilient to energy price shocks if its productivity is not adversely affected, while van de Ven and Fouquet (2014) find that resilience to energy shocks has improved over time. Drawing on a wider literature, Matzenberger (2013) proposes that resilience is interlinked with adaptive capacity and vulnerability. For the purposes of its analysis, the Panel defined *resilience* as the capacity of firms to adjust or adapt to events such as a rise in energy prices or, in other words, to bounce back from them.

Successful adjustment involves both proportionately lower energy use and limited adverse impacts on productivity or sales.[22] Higher productivity would indicate that a firm has remained successful in producing more output per worker

22 Growth in gross income for an industry will increase over time in line with increased marginal productivity of labour and product prices. The distribution of that gross revenue between profits and salaries will depend on an industry's circumstances. However, industry profits are, in general, correlated with growth in both the value of output and in average productivity.

despite higher energy prices. A significantly higher growth in the value of output — meaning that the prices of the products sold were increasing — would result in an increase in the sector's overall profits. Ideally, sectors would exhibit increases in productivity and/or the value of output in response to higher energy prices.[23]

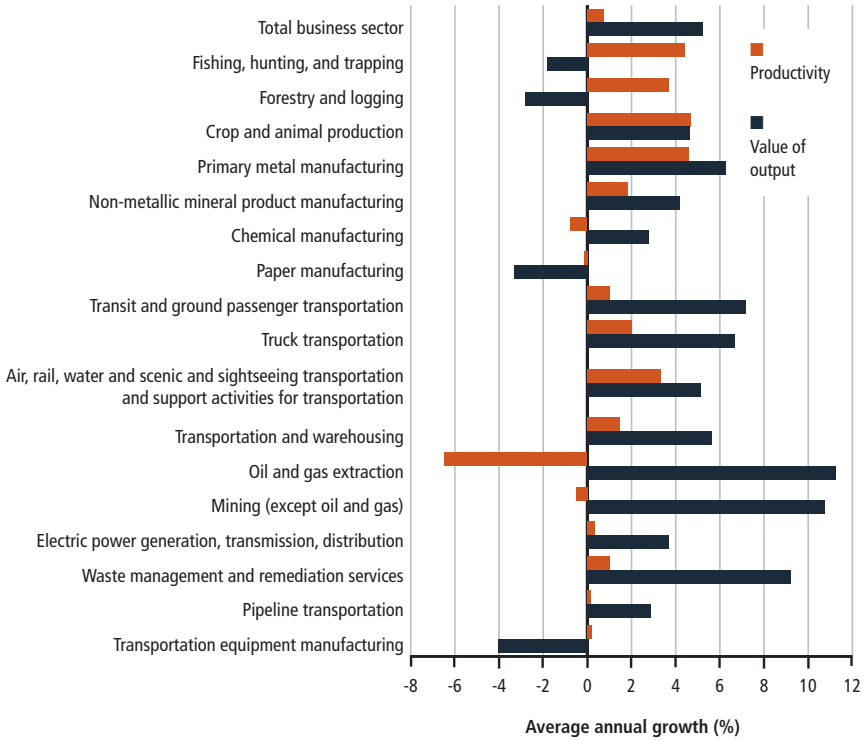
Figure 4.1 shows the average annual growth rates in productivity and the value of output, by industry, from 2000 to 2008, a period of rising energy prices. When aggregated, these industries constitute the eight sectors that the Panel determined would be exposed to energy prices in Chapter 3. The first lines of data in the figure relate to the performance of the overall business sector in Canada (i.e., includes industries not exposed to energy prices as well as exposed industries). The data show that productivity growth has been relatively weak overall in Canada, consistent with other studies. In general, the growth rates in productivity in sectors exposed to energy prices have not been out of line with overall performance of the Canadian business sector, with a few notable exceptions.

First, some industries in particular faced challenges over the last decade with flat or negative productivity growth, coupled in some instances with declining value of industry output (probably as the industry contracted in size). This group includes the paper, chemical, and transportation equipment manufacturing industries. Second, although the output of the fishing, hunting and trapping, and forestry and logging industries declined, this effect was offset by higher productivity.[24] Third, productivity declined in the oil and gas extraction and mining industries. As Almon and Tang (2011) and Sharpe & Long (2012) discuss, rising energy prices encouraged these industries to increase their rate of exploration and extraction of more marginal reserves, which lowered their productivity. Simultaneously, they experienced higher profits as suggested by the rapid growth in the value of their output. For these industries, the most appropriate metric of strong performance is the value of gross output (which approximates to sales). Clearly, the oil and gas extraction industry benefits from rising energy prices.

23 In episodes of rising energy prices, resources may be diverted from increasing output to economize on energy costs. Using data from the United States, Hassler *et al.* (2012) show that growth in energy-saving technology has been negatively associated with growth in productivity-enhancing technology: the trend in energy-saving technology was faster in the 1970s as oil prices rose relative to factor-augmenting technology, but then slower in the 1980s as oil prices fell back.

24 Higher productivity growth coupled with a decline in the value of products produced by an industry could be a sign that less efficient plants are exiting the industry.

This parsing of the data does not yield insight into whether challenges for these three industries — paper, chemical, and transportation equipment manufacturing — were primarily because of higher energy prices or other structural trends over the last decade. Closer analysis of all sectors exposed to energy prices undertaken in Section 4.5 helped the Panel to come to a more nuanced understanding of the role of energy prices. In particular, the paper manufacturing industry faced more fundamental challenges, such as the digitization of media, which lowered demand for newsprint. The chemical manufacturing industry was adversely affected by the increasing price of oil



Data Source: Panel calculations based on Statistics Canada (2014a, 2014b)

Figure 4.1

Average Annual Growth in the Value of Output and Productivity in Canadian Industries Exposed to Energy Prices, and Total Business Sector, 2000–2008

The figure shows growth rates in productivity and the value of output across industries. Productivity growth has been weak in many industries in Canada, but higher prices and greater production could be an indicator of industry strength in those influenced by the prices of natural resources.

relative to natural gas, a pattern that has now reversed. The transportation equipment manufacturing industry faced challenges of over-capacity in North America. In this latter case, however, it may well be that consumer demand was moving towards more energy-efficient equipment, and that firms based in North America did not adjust rapidly enough.

4.2 IMPACTS OF RISING ENERGY PRICES ON INTERNATIONAL COMPETITIVENESS

As a direct measure of competitiveness impacts of changing energy prices, the Panel set out to compare the data on energy intensities across countries. At the most basic level, business performance is based on having modern equipment and effective operational and management techniques. In this respect, domestic and international benchmarking studies of energy efficiency are available for many industries in Canada, such as for the pulp and paper industry (NRCan, 2008) and the steel industry (NRCan, 2007). These studies supply information such as the amount of energy used (measured in joules) per unit of physical output (such as tonnes of cement or steel). As discussed in Chapter 3 and Chapter 6, this type of information is valuable to business managers because it provides the basis for more informed decision-making.

However, it is difficult to use this kind of information to provide an overview of the state of competitiveness of Canadian business. The low price of energy in Canada (as discussed in Chapter 2) makes it less worthwhile to invest in highly energy-efficient equipment relative to other countries, or even to search for such possibilities. Hence, being less energy efficient in physical terms compared with plants in other countries may not be a sign of competitiveness concern in Canada. Rather, it may reflect a rational business decision based on cheaper energy. As discussed in Chapter 3, it may well be easier for Canadian-based firms to improve their energy efficiency by following the roadmap to energy efficiency laid out for them by European competitors. Furthermore, the data on energy efficiency comparisons in physical units are not usually available on comparable sector bases across countries. Rather, they are more likely to be plant-to-plant comparisons.

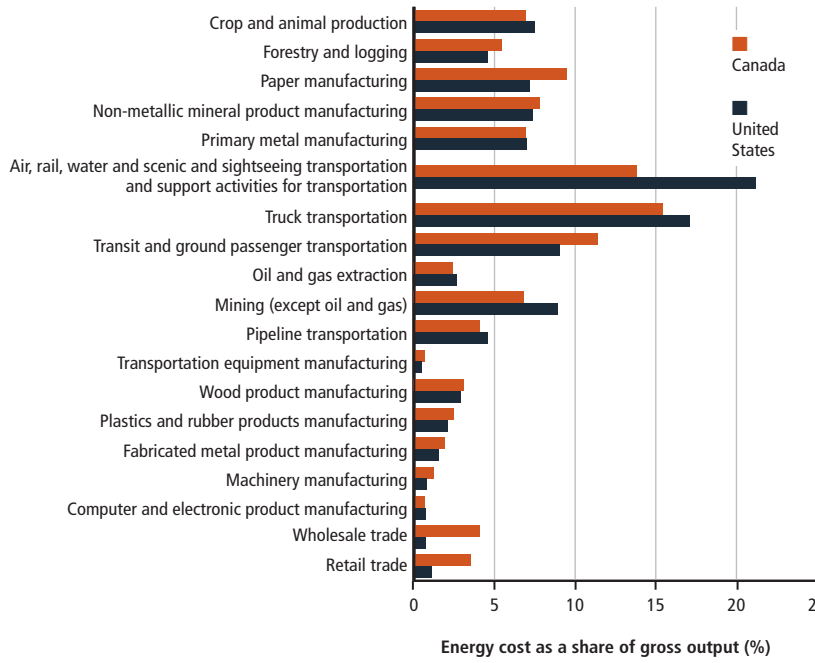
To take energy prices into account, and assess whether low energy prices in Canada would be sufficient to offset any greater energy use stemming from them, it is helpful to compare energy costs as a proportion of sales for comparable sectors in Canada and other countries. A higher share of energy costs for a sector in Canada would mean that a similar percentage increase in energy

price across countries would translate into greater absolute cost increases in the Canadian sector, assuming similar adjustment options. This would harm the competitiveness of the sector.

The Panel did not find any readily available data that allow industry or sector comparisons of the energy intensity of Canadian firms and that of firms in countries other than the United States. The Panel examined data from Statistics Canada and the U.S. Bureau of Economic Analysis (BEA). These data had the advantage of having sector definitions conforming to a common NAICS basis.[25] Figure 4.2 shows the cost of energy as a share of the value of gross output (i.e., energy intensity) across industrial sectors. The overall picture that emerges is that there are no large differences between Canada and the United States in the degree of energy intensity, particularly in manufacturing industries. Differences in service industries could reflect greater need for winter heating in Canada than in the United States. For those industries that provide goods and services that are not traded across borders, there would be no competitiveness impacts from higher energy intensities in terms of lost market share to international competitors, although consumers may switch purchases to less energy-intensive products in the long term.

Unfortunately, Canada and the United States use different methodologies in reporting fuel use in the economic data. In economic data, all costs can be allocated among capital, labour, energy, material, and service inputs, but some fuels can be both material inputs into production (e.g., using natural gas as a feedstock to manufacture chemicals) and energy sources (e.g., using natural gas to generate electricity). However, all expenditure on natural gas in the economic accounts is reported as energy costs in Canada, whereas data in the United States allocate a proportion of natural gas expenditures in the chemical industry to material costs. These differences are important in comparing energy cost shares in particular industries across Canada and the United States, such as in petroleum and coal products manufacturing, chemical manufacturing, and waste and remediation services. These industries are, therefore, not displayed in Figure 4.2 because the data show an artificially wide gap in energy intensities stemming from methodological differences between statistical agencies rather than from real differences.

25 Some definitional differences remain, such as fishing not being available separately in BEA data.



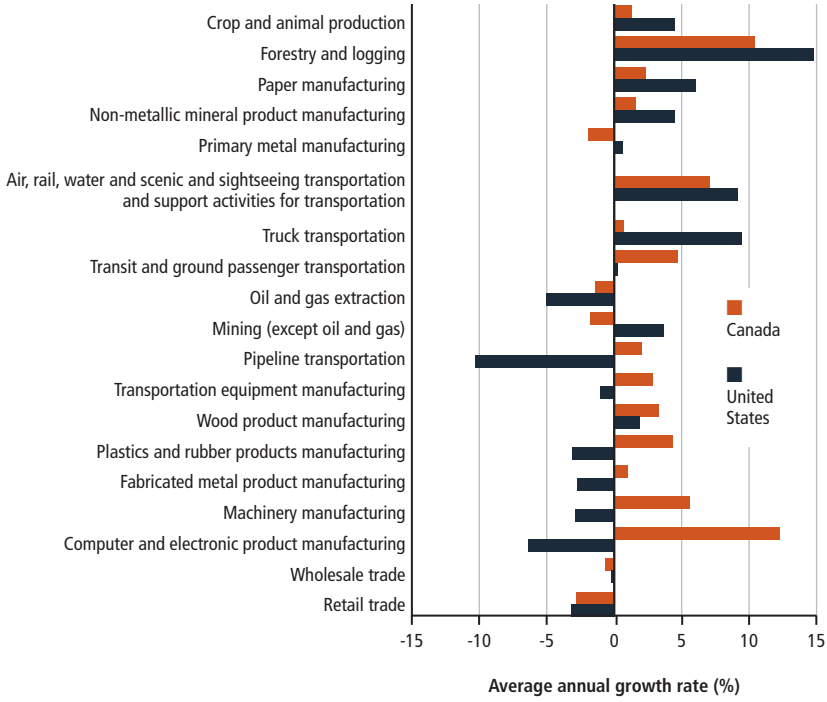
Data Source: Panel calculations based on Statistics Canada (2014g) and BEA (2013)

Figure 4.2

Average Energy Intensity by Industry, Canada and the United States, 2004–2008

The figure shows that energy intensities (energy cost as a share of the value of gross output) across Canadian industries are roughly consistent with their competitors' energy intensities in the United States. Data for comparing energy intensity are not available for chemical manufacturing, petroleum and coal products, and waste management because of methodological differences between BEA and Statistics Canada. The forestry and logging industry in the United States includes the fishing, hunting, and trapping industry.

Figure 4.3 shows the growth in energy intensity (energy costs as a share of gross output) across industries in Canada and the United States for the 2000–2008 period of rising energy prices. Many of the energy-intensive Canadian industries show smaller increases in energy intensity than their competitors in the United States, suggesting that at least energy-intensive industries had taken action to contain energy costs. One contributing factor is that energy prices increased proportionately by more in the United States than in Canada because the rising Canadian dollar held down the cost of those energy sources, whose benchmark prices are normally in U.S. dollars.



Data Source: Panel calculations based on BEA (2013) and Statistics Canada (2014g)

Figure 4.3

Growth in Energy Intensity by Industry in Canada and the United States, 2000–2008

This figure shows the growth in energy intensity (energy cost as a share of the value of gross output). Many of the energy-intensive Canadian industries show smaller increases in energy intensity than their competitors in the United States, suggesting that many firms had taken action to contain energy costs.

4.3 BUSINESS ADJUSTMENT TO RISING ENERGY PRICES

Even if levels of energy intensity are high in some sectors in Canada relative to other countries, firms can adjust over time if energy prices continue to rise. Indeed, as discussed in Chapter 3, it may only make sense for firms to act when they detect a persistent trend in energy prices. Hence, to examine whether changing energy prices have significant competitiveness effects, it is useful to look at trends in the quantity and cost of energy use in proportion to output in periods of rising energy prices to see how firms adjusted to the higher prices. Incorporating changes in output is important in this exercise because the changing size of sectors over time will also influence the quantity of energy used, as well as improvements in energy efficiency.

In the face of higher energy prices, a firm's energy costs usually rise as a share of sales since the demand for energy is generally price inelastic, particularly in the short run.[26] A characteristic of an inelastic factor input is that the share of a firm's budget spent on that product will change in the same direction as its price. Therefore, while energy costs as a share of sales increase with energy prices in the short run, the physical quantity of energy used in proportion to physical output will likely decline over time because firms adjust to economize on energy use. An industry that is finding it challenging to cope with higher energy prices would be one whose capacity to economize on energy use is limited. Hence, an industry adversely affected by energy prices would be one whose energy costs have increased as a share of sales, while the amount of energy used per unit of output has not declined proportionately.

Data to examine such trends do not appear to be reported systematically on an international basis. As such, the assistance of a specialized organization would be required to overcome differences in sector definitions and methodologies across countries. Mulder and deGroot (2012) highlighted these concerns in their use of a dataset covering many developed economies. The dataset included economic data on energy from national and European databases (but not Canada), and data on physical units from the IEA. Although international comparisons with countries other than the United States do not appear to be possible, trends in these variables can be compared within Canada.

The Panel examined Canadian industry trends from 2000 to 2008 in energy intensities both in terms of costs and quantities (see Table 4.1). This period experienced rising energy prices, forming a coherent period in which to examine their potential impacts. The last year for which all data were available was 2008, but using more recent data, had it been available, would have conflated the impact of energy prices with the recession. The economic performance of industries, which are grouped into the sectors the Panel defined as exposed to changing energy prices, gives clues as to how they may perform in the face of higher energy prices going forward, and provides a base for deeper examination later in the chapter.

The first column of data in Table 4.1 shows the average annual growth rate in gross output in real terms (i.e., excluding the impact of the price changes shown in Figure 4.1). The same group of industries (e.g., transportation equipment and paper manufacturing) as used in the analysis in Figure 4.1 shows declines in

26 The elasticity of a product represents the ratio of the percentage change in quantity demanded of the product to the percentage change in its price. An inelastic product is one where the percentage change in the quantity demanded is less than the percentage change in price.

output. Industries linked to oil and gas extraction and mining now show more modest increases in output because the effect of price increases is removed. The next column shows the growth rate in physical units of energy.

The next two columns in the table show the change in the use of energy proportional to output, first in terms of the cost of energy in proportion to the value of output, and then in terms of the quantity of energy used in proportion to the quantity of output. Since this period saw rising energy prices, the rate of increase in the cost of energy in proportion to the value of output will be greater, in general, than the rate of increase in the quantity of energy in proportion to the quantity of output. An important exception is those industries that produce energy or products whose price is likely to have been heavily correlated with energy (e.g., because of growing demand for them stemming from rapid growth in developing economies). Consequently, the share of the cost of energy as a proportion of sales declined in the oil and gas and mining sectors because the value of their output increased to an even greater extent than their energy costs.

In general, the data show that industries have adapted to higher energy prices by improving their energy efficiency. Figure 4.4 shows the average annual change in energy in proportion to output, by industry, during the 2000–2008 period of rising energy prices. Of the 18 industries displayed, fully 14 lowered their energy intensity by this metric, 1 industry was unchanged, and energy intensity increased in 3. Decreases ranged from an annual average decline of 4.7% in retail trade services to an average increase of 2.1% in forestry and logging.

Table 4.1

Economic Statistics on Sectors in Canada, 2000–2008

Sectors	Industries by Statistics Canada name (%)	Average annual growth, 2000–2008				Cost of energy as a share of gross output, 2008 (%)
		Real gross output (%)	Energy input (%)	Cost of energy as a share of the value of output (%)	Quantity of energy as a share of the quantity of output (%)	
Energy-intensive: resource-based	Crop and animal production	2.0	0.5	1.3	-1.4	6.9
	Forestry and logging	-3.3	-1.3	10.4	2.1	6.7
	Fishing, hunting, and trapping	-1.2	-4.5	3.6	-3.4	16.4
Energy-intensive: manufacturing	Paper manufacturing	-2.6	-3.5	2.3	-0.9	9.8
	Chemical manufacturing	0.1	0.1	5.1	0.0	14.9
	Non-metallic mineral product manufacturing	2.2	0.0	1.6	-2.2	7.9
	Primary metal manufacturing	2.2	0.8	-1.9	-1.4	6.7
Energy-intensive: transportation services	Air, rail, water and scenic and sightseeing transportation and support activities for transportation	2.5	3.3	7.0	0.8	17.6
	Truck transportation	3.9	-0.4	0.7	-4.2	17.5
	Transit and ground passenger transportation	3.6	4.6	4.7	1.0	13.1

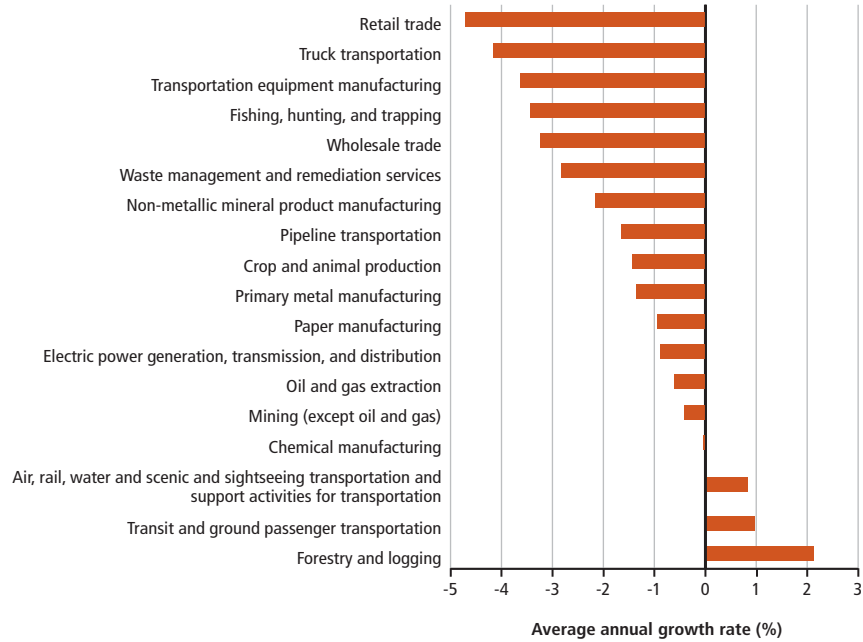
continued on next page

Sectors	Industries by Statistics Canada name (%)	Average annual growth, 2000–2008: Real gross output (%)	Energy input (%)	Cost of energy as a share of the value of output (%)	Quantity of energy as a share of the quantity of output (%)	Cost of energy as a share of gross output, 2008 (%)
Capital-intensive: oil and gas	Oil and gas extraction	1.8	1.2	-1.4	-0.6	2.0
Capital-intensive: mining	Mining (except oil and gas)	1.2	0.8	-1.8	-0.4	6.6
Capital-intensive: electric power	Electric power generation, transmission, and distribution	1.9	1.0	3.0	-0.9	13.8
Capital-intensive: other	Pipeline transportation	-0.1	-1.7	2.0	-1.7	4.7
	Waste and remediation services	7.8	4.8	0.9	-2.8	8.4
Transport equipment	Transportation equipment manufacturing	-2.6	-6.1	2.9	-3.6	0.7
Other services	Wholesale trade	4.1	0.8	-0.7	-3.2	4.3
	Retail trade	3.9	-1.0	-2.8	-4.7	3.5

Data Source: Panel analysis based on Statistics Canada (2014g)

Labour productivity is measured as gross output per hour worked. Energy input is obtained by chained-Fisher aggregation of various energy inputs purchased for use as heat or power including electricity, fuel oil, coal, natural gas, and other miscellaneous fuels. Energy cost share is calculated as the cost of energy input divided by GDP in current dollars. Energy intensity is calculated as the growth in energy input relative to the growth in real gross output. Energy cost is the cost of energy input as a share of GDP.

For example, although the energy costs of non-metallic mineral product manufacturing industries increased at an average annual rate of 1.6% over the eight-year period, they managed to lower the amount of energy used in



Data Source: Panel calculations based on Statistics Canada (2014f)

Figure 4.4

Average Annual Growth in the Quantity of Energy Used Relative to the Quantity of Output, by Industry in Canada, 2000–2008

The figure shows that the quantity of energy used has declined relative to the quantity of output produced in many industries as energy prices rose since 2000.

proportion to quantity of output by 2.2% per year. Had they not taken action to adjust and adapt, they would have faced an even greater rise in energy costs over the period.

The data suggest once again that the industries that apparently did not lower their energy use were forestry and logging, chemical manufacturing, and some of the transportation service industries. The quantity of energy used in proportion to quantity of output increased for these industries despite higher prices. The transportation service industries did manage to cope, however, as their real output increased quite rapidly, as did their productivity and the value of their sales (as reported in Figure 4.1).

4.4 BUSINESS FUEL USE PATTERNS

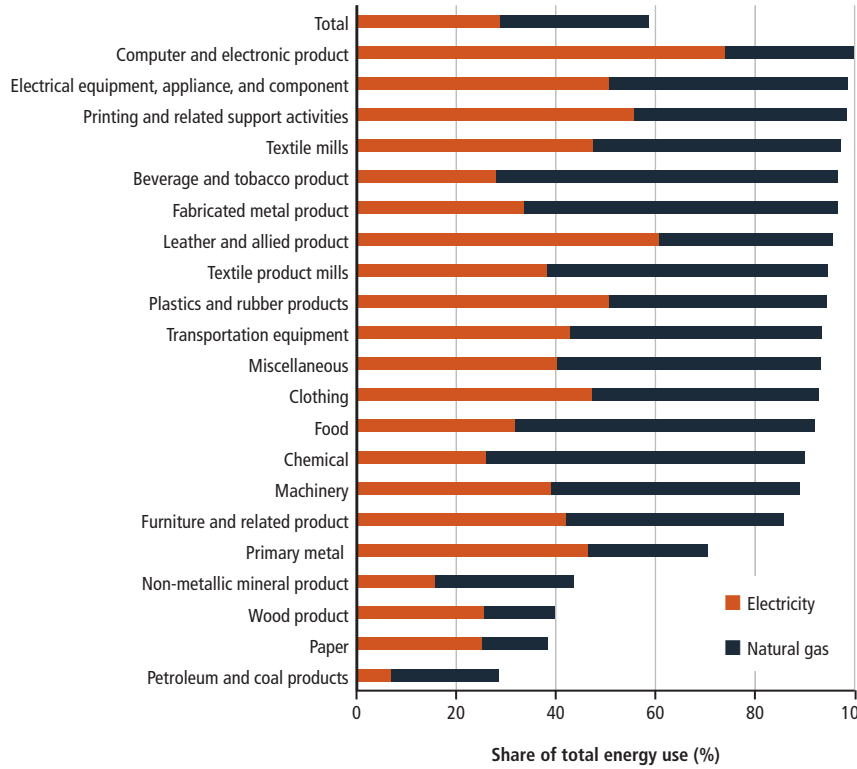
Another consideration in examining industry exposure is the pattern of fuel use. Since the fuels used as sources of energy differ across sectors, the exposure of sectors to energy prices may diverge if the prices of these fuels become less interlinked. As shown in Figure 4.5, about 60% of energy used by manufacturing industries[27] in Canada comes from burning natural gas or consuming electricity. However, this ratio reaches almost 100% in the computer and electronic product manufacturing industry.

Industries that use fuels other than natural gas or electricity often have unique sources of energy. The primary metal manufacturing industry (which includes steel production) obtains 20% of its energy from coking coal; non-metallic mineral product manufacturing (which includes cement production) gets energy from a variety of sources, including 11% from petroleum coke; wood product manufacturing obtains 47% of its energy from wood; and paper manufacturing obtains 38% of its energy from spent pulping liquor (also known as black liquor). As a result, the only major manufacturing industry that uses significant amounts of petroleum products is petroleum and coal products manufacturing (which includes refinery use of crude oil).

By contrast, transportation services mostly use oil-based products such as diesel, aviation, or bunker fuel. All modes of transportation (i.e., including for household and business use) account for 71% of the use of oil-based products in Canada (IEA, 2013b) and 70% in the United States (EIA, 2013b). The transportation of goods to market is likely to remain exposed to trends in global oil markets, and therefore could be a source of vulnerability for industries that spend heavily on transport. In particular, firms that are located far from their markets could face significant impacts, which is more likely in some of the remote locations in Canada.

Going forward, as discussed in Chapter 2, electricity and natural gas, the two major sources of energy for the majority of manufacturing, are both likely to remain cheap in many parts of Canada, relative to other countries. This is due to Canada's large hydroelectric power capacity and the availability of natural gas, which can be used directly or to generate electricity. Consequently, competitive pressures from energy costs on Canadian manufacturing compared with other countries are likely to remain muted. It appears that some Canadian manufacturing firms have already taken advantage of the opportunities from

27 Data on fuel use are not available for all industries. The types of fuel used to generate electricity were discussed in Chapter 2.



Data Source: Panel calculations based on Statistics Canada (2012)

Figure 4.5

Proportion of Energy Use from Electricity or Natural Gas in Canadian Manufacturing, 2011

The figure shows that electricity and gas are the most important sources of energy input in the manufacturing sector, and for almost all industries within the sector. Data for total manufacturing are the weighted average of all manufacturing industries.

cheaper gas. The share of natural gas in total energy used in manufacturing in Canada increased from 26% in 2006 to 30% in 2011 after being in constant decline for the previous decade (Statistics Canada, 2014j).

4.5 DETAILED SECTORAL ANALYSIS

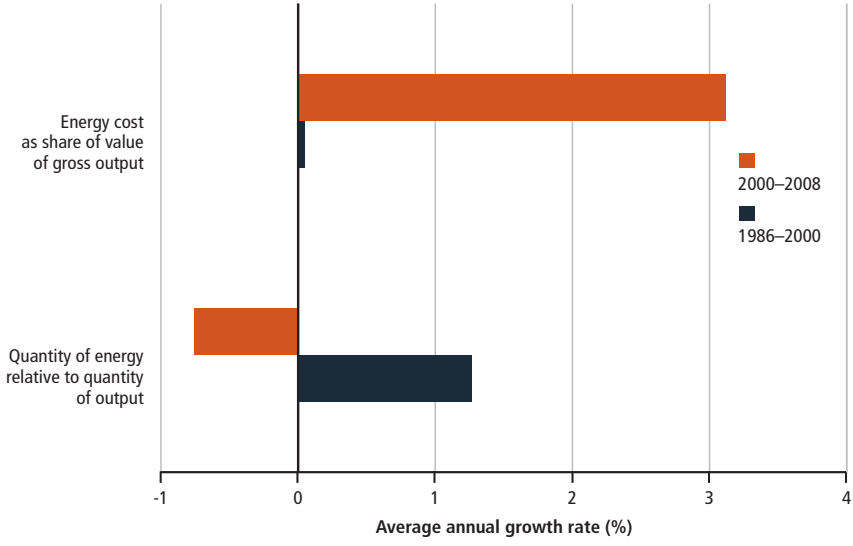
To gain a deeper understanding of how and why industries in the sectors chosen by the Panel responded in the past to energy prices, this section reviews available literature and data on their individual experiences. It examines in greater detail trends in energy intensities — reported both as the cost of energy as a share of gross output and as the quantity of energy used relative to the quantity of output — and compares them across different periods. From 2000 to 2008, the

price of energy was generally rising, while from 1986 to 2000 the price of oil was much lower and more stable. Through its sectoral analysis, the Panel also seeks to determine if the challenges for certain industries identified in earlier sections were the direct result of energy prices or if there were other factors at play. Where possible, the Panel also notes the potential implications of some of the trends identified in Chapter 2 for specific industries.

4.5.1 Energy-Intensive Resource-Based Sector

This energy-intensive sector, which includes all of animal and crop agriculture, forestry, and fishing industries, is more evenly distributed across Canada than many of the other sectors. Ontario accounts for 20% of Canadian establishments, followed by Alberta and Saskatchewan with 19% each, and Quebec with 17% (Statistics Canada, 2014g).

Over recent years, energy costs in the sector have risen as a share of sales, but energy intensity has generally improved. While becoming more energy intensive when energy prices were low, the sector improved its energy efficiency as the price of energy started to rise in 2000 (see Figure 4.6), suggesting that the sector



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.6

Resource-Based Sector: Average Annual Changes in Energy Intensity, 1986–2008

The figure shows that energy costs have become a bigger share of the value of gross output since 2000 in the resource-based sector (which includes the animal and crop agriculture, forestry, and fishing industries). However, the sector has lowered the amount of energy it uses per unit of output.

was able to adjust. The forestry and logging industry, however, experienced higher energy costs and higher energy intensity at a time of falling output and employment.

Because the sector relies significantly on petroleum-based products such as diesel, it will continue to be affected by changes in the world price of crude oil. It will also be affected by changes in world markets for the prices of its products, as it produces globally traded agricultural and forest-based commodities. Increasing energy costs are therefore likely to be felt immediately given the limited opportunities to offset costs by charging higher prices.

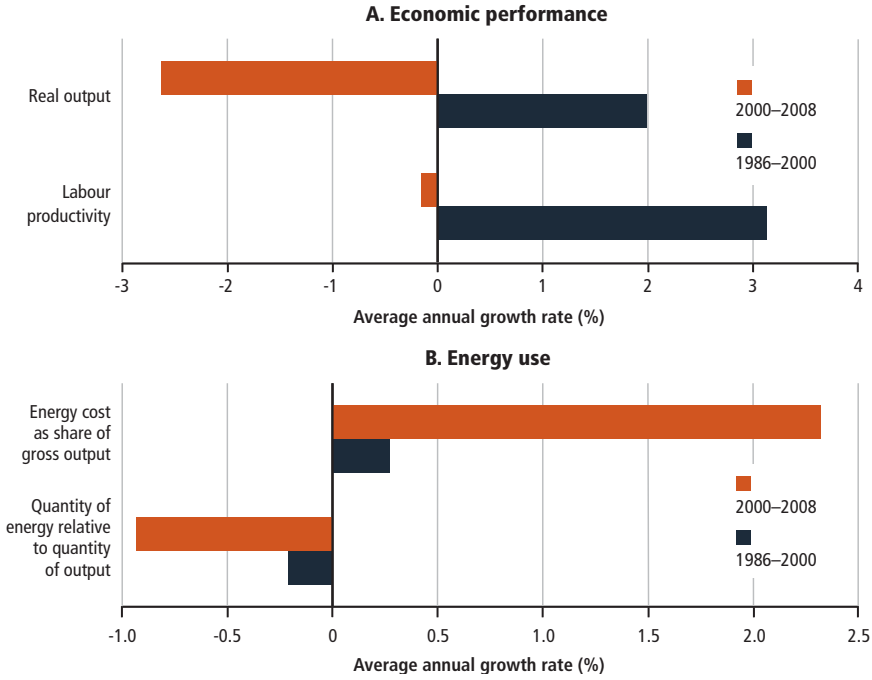
4.5.2 Energy-Intensive Manufacturing Sector

This sector includes paper, chemical, non-metallic mineral product, and primary metal manufacturing. The aggregate metrics of output and productivity performance suggest that the chemical and paper manufacturing industries were under pressure in 2000–2008 when energy prices rose. The non-metallic mineral product and primary metal manufacturing industries fared better in this period with output and productivity increasing while energy intensity declined.

Paper

The paper manufacturing industry includes firms primarily engaged in manufacturing pulp, paper, and paper products. The manufacture of pulp involves separating the cellulose fibres from other impurities in wood, used paper, or other fibre sources. The manufacture of paper involves matting these fibres into a sheet. Converted paper products are produced from paper and other materials by various cutting and shaping techniques. In 2010, 10 of the 21 plants employing 500 or more people were in Quebec, 5 were in Ontario, and 4 were in British Columbia (Industry Canada, 2014b).

The paper manufacturing industry has faced significant challenges over the last decade, which can be seen in Panel A of Figure 4.7. Demand for newsprint dropped with the digitization of media, and demand for printing and writing paper is also in structural decline. Although pulp can still be sold on global markets, there is increased competition as technological change allows hardwood lumber to be used in its manufacture. The industry, however, has adapted. Panel B of Figure 4.7 shows that the pace of energy intensity improvement accelerated as energy prices rose. Adès *et al.* (2012) looked at how the industry moved away from using fuel oil, for instance, and thus lowered its exposure to the world price of crude oil. Going forward, the industry can benefit from continuing to produce its own clean energy to sell to the electricity grid, as well as producing more biochemical and advanced materials.



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.7

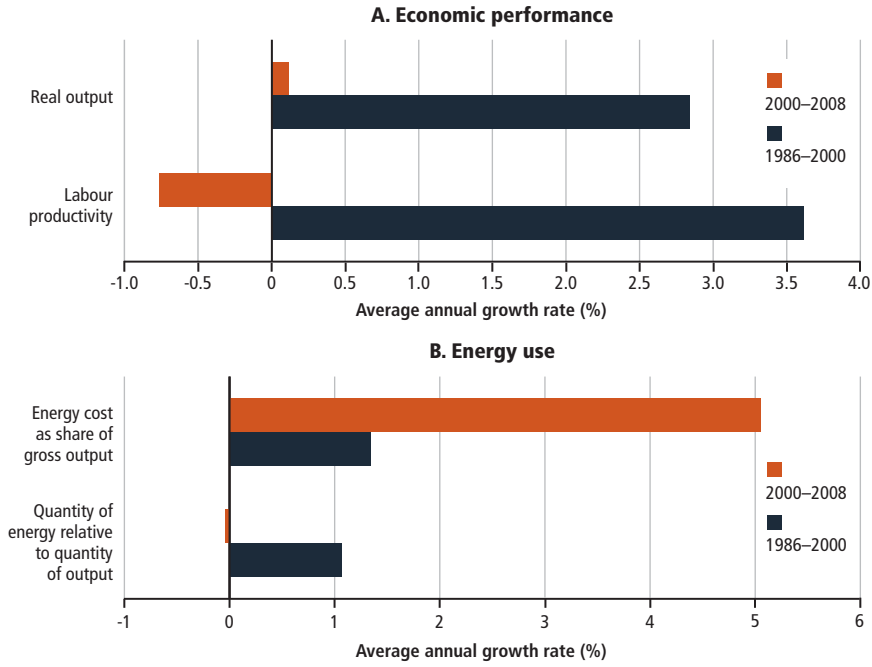
Paper Manufacturing: Average Annual Changes in Output, Productivity, and Energy Intensity, 1986–2008

The paper industry has faced significant challenges over the last decade. Demand for newsprint dropped with the digitization of media, and demand for printing and writing paper is also in structural decline. As the cost of energy increased since 2000, the sector has improved its energy efficiency.

Chemicals

This industry includes 2,087 plants manufacturing a wide range of chemicals, resins, synthetic rubber, pesticides, chemical fertilizers, pharmaceuticals, paints, and explosives. Of these plants, 40% are located in Ontario, 27% in Quebec, and 12% in both Alberta and British Columbia (Industry Canada, 2014b).

The economic statistics highlighted in Section 4.1 suggested that chemical manufacturing was challenged by higher energy prices. Panel A of Figure 4.8 shows that output stagnated and productivity declined sharply after 2000. Furthermore, although energy costs rose as a share of output, the quantity of energy used in proportion to the quantity of output did not improve (Panel B).



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.8

Chemical Manufacturing: Average Annual Changes in Output, Productivity, and Energy Intensity, 1986–2008

The cost of energy increased as a share of the value of output for the chemical manufacturing industry. The main challenge for the industry, however, was the high price of natural gas relative to oil, which led to investment outflow. This price pattern has now reversed.

However, this industry uses large quantities of natural gas as a feedstock to produce products such as ethylene, the base for products ranging from carrier bags to detergents. In contrast, much of the production of chemicals in the rest of the world is based on naphtha, which is transformed from crude petroleum. Consequently, the high price of natural gas relative to oil during much of the last decade left this industry at a disadvantage relative to competitors outside of North America. Inefficient plants were closed and new investment was forgone in favour of building new plants in the Middle East.

There is only a clear cost advantage for oil-based chemical firms when the market price of oil relative to natural gas is less than about 7 to 1 (ACC, 2011). As the price of oil rises beyond a ratio of about 10 to 1, natural gas-based producers come to the fore.[28] Over the past few years, breakthroughs in extracting natural gas in North America mean that the price ratio is close to 30. Even when compared with firms in the Middle East that are using natural gas liquids, North American-based firms now have a cost advantage. Since the central determinant of the industry's performance is this relative price, the industry could potentially benefit from higher oil prices relative to natural gas in the future. With improved extraction techniques, industry experts see this relative price differential remaining. Large-scale plants are planned to come on-stream that will benefit the industry's overall performance. For instance, by the end of 2015, NOVA Chemicals will open a new polyethylene production line in Joffre, Alberta (NOVA Chemicals, 2014) and will invest approximately $300 million between 2014 and 2018 to increase the ethylene capacity of its Ontario plants (NOVA Chemicals, 2013). Meanwhile Sasol is planning to build Canada's first gas-to-liquids (GTL) facility near Edmonton, Alberta (SASOL, 2012).

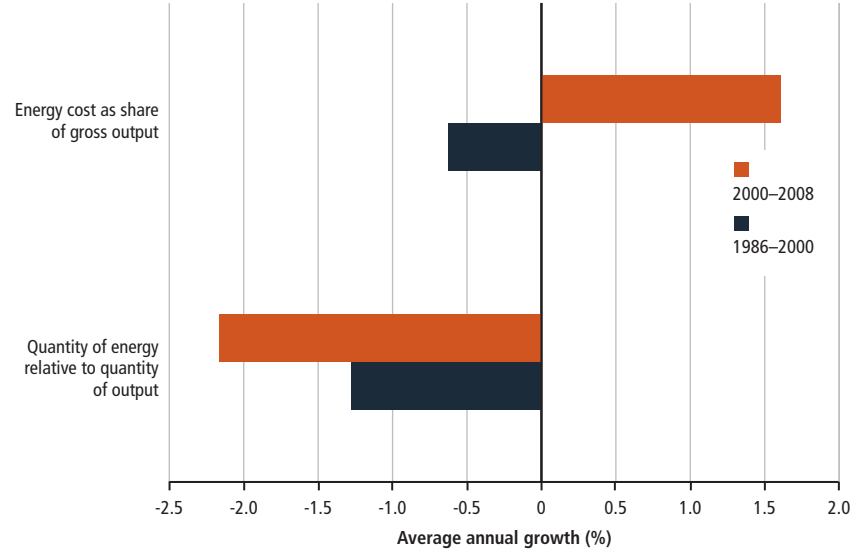
Another component of the chemical manufacturing industry is the production of nitrogen-based fertilizer, which is produced from natural gas. Lower costs give this fertilizer a cost advantage relative to other products used by farmers.

Non-Metallic Mineral Products

This industry includes plants involved in producing lime, bricks, glass, and cement. Ontario and Quebec account for 61% of the 2,361 plants in Canada (Industry Canada, 2014b). Some component industries, such as cement, tend to use a wide range of fuels, such as coal or petroleum coke.

Figure 4.9 suggests that the industry has coped relatively well with higher energy prices. The quantity of energy relative to output declined constantly, and the pace of decline accelerated as prices rose.

28 Note that this price is not adjusted for energy equivalence, as this concept is not meaningful in this context. The 7:1 ratio used by the American Chemistry Council (2011) is calculated by evaluating the competitiveness of Gulf Coast-based petrochemicals plants: the ratio of the price of oil based on the West Texas Intermediate price in terms of U.S. dollars per barrel, to the price of natural gas based on the Henry Hub price in terms of U.S. dollars per million BTU.



Data Source: Panel calculations based on Statistics Canada (2014g)

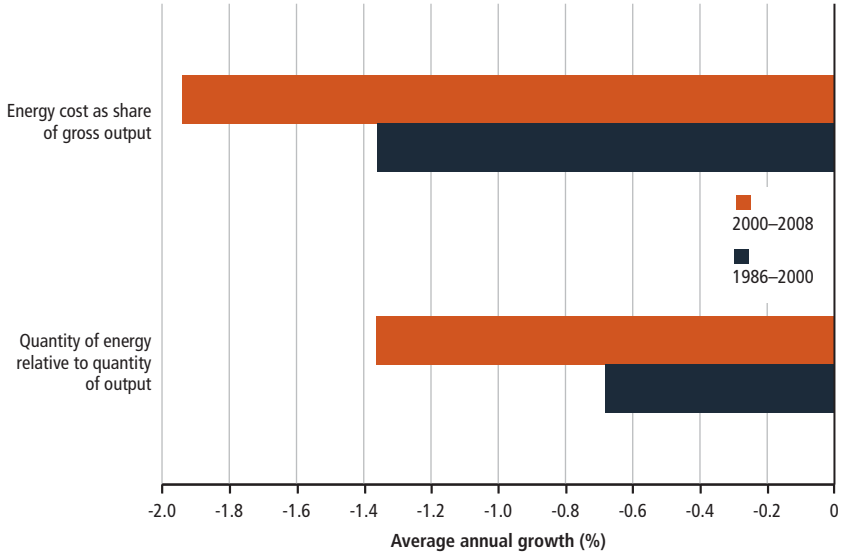
Figure 4.9

Non-Metallic Mineral Product Manufacturing: Average Annual Changes in Energy Intensity, 1986–2008

As energy costs rose as a share of the value of gross output, this sector has reduced its energy use even further as a share of its production. This industry includes plants involved in producing lime, bricks, glass, and cement.

Primary Metals

Primary metal manufacturing includes iron and steel smelting and aluminium production, and other metals such as copper, zinc, nickel, and lead, as well as foundries for iron, steel, aluminium, and other non-ferrous metals. Ontario and Quebec account for 75% of total plants in Canada. Of the 32 plants with 500 or more employees, 14 are in Quebec and 11 in Ontario (Industry Canada, 2014b). Many of the component smelting industries, such as aluminium, use large amounts of electricity, which they can either generate themselves or buy on long-term contracts. Again, the evidence suggests that this industry coped well with rising energy prices with the cost and quantity of energy both declining as a share of output (see Figure 4.10).



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.10

Primary Metal Manufacturing: Average Annual Changes in Energy Intensity, 1986–2008

This sector has reduced both the quantity and cost of energy used in production, a trend that accelerated as energy prices rose. Primary metal manufacturing includes iron and steel smelting and aluminium production, and other metals such as copper, zinc, nickel and lead, as well as foundries for iron, steel, aluminium, and other non-ferrous metals.

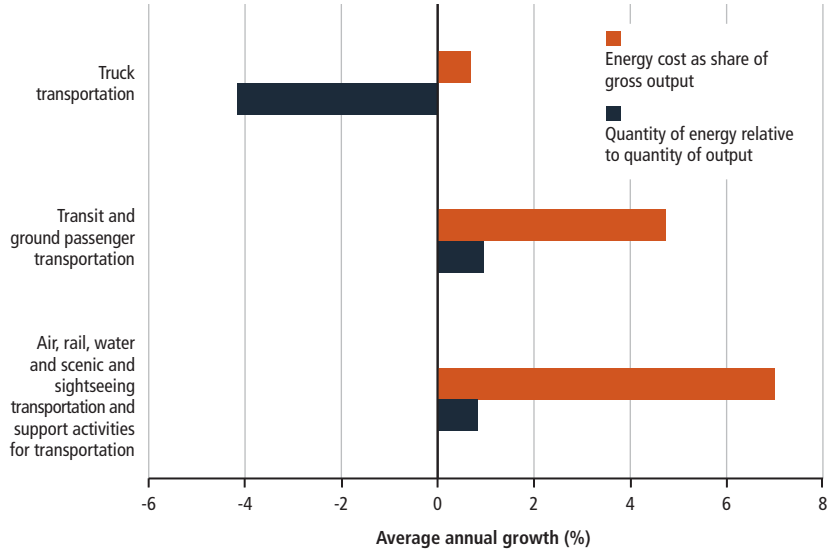
4.5.3 Energy-Intensive Transportation Services Sector

The transportation services sector includes firms that own trucks, buses, aircraft, trains, and boats that transport goods and people. As mentioned in Section 4.4, collectively they account for about 70% of the use of oil-based products such as gasoline, diesel, and bunker and aviation fuels. Transportation services play a key role in linking factories in complex supply chains throughout the world, and then in taking final goods to market. Their use, therefore, tends to closely track economic activity. In this role, they transmit changes in global oil prices into the costs of other industries.

Over the most recent period examined, from 2000 to 2008, the truck transportation industry improved its energy efficiency markedly so that the cost of energy used did not increase significantly for the industry (see Figure 4.11). Although other transport services saw greater increases in energy costs and failed to improve their energy efficiency, the rapid growth in the value of their output and productivity over the same period suggests that they managed to absorb higher energy prices.

Technology, new investments, and new operating practices can improve energy efficiency. Trucking firms have introduced in-cab heaters to avoid running the engine to keep cabs warm in the winter (Partners in Project Green, 2009). Improved aerodynamics and enforcing speed limits on truckers have helped operating efficiency. As a result of these and other initiatives, the on-road average fuel consumption of trucks improved from 42.5 litres per 100 kilometres in 1990 to 33.4 litres per 100 kilometres in 2009 (NRCan, 2011). It appears that higher energy prices were a strong incentive for this industry to improve its energy efficiency. New government fuel economy regulations for heavy-duty trucks are scheduled to begin in 2014 (Environment Canada, 2013).

In the global airline industry, fuel costs as a share of operating costs rose from 12–13% in 2001–2003 to 32% in 2008 (IATA, 2013). Despite this significant rise, its pace was slower than the increase in the price of oil in this period, which suggests that airlines' operational efficiency increased and/or they found other means of offsetting energy costs.



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.11

Transportation Services: Average Annual Changes in Energy Intensity, 2000–2008

The transportation services sector includes many different types of services including trucking, transit, rail, and air transport. The cost of energy increased with energy prices, but the sector reduced its energy use relative to its level of output.

Going forward, transport services industries can benefit from exploiting cheaper natural gas. The EIA (2013a) reports natural gas to be economic for heavy trucks with the lower price of natural gas providing an incentive to switch from oil to gas. Train operators in Canada are also exploring how to take advantage of lower natural gas prices (CN, 2012).

4.5.4 Capital-Intensive Oil and Gas Sector

The oil and gas sector is involved in extraction of both conventional and unconventional sources of natural gas and oil. The sector benefitted over the past decade from higher energy prices resulting from growing demand in Asia. Of the 4,613 firms in Canada, 78% are in Alberta, and 8% in both Saskatchewan and British Columbia (Industry Canada, 2014b).

Although this sector does use energy, the price of energy has a greater effect on its output. Even if it becomes more energy intensive in its production as the price of energy rises, the cost of energy as a share of the value of its sales will probably decline. The opposite will also happen, as occurred in the mid-1980s when the price of oil crashed. As such, energy intensity is not an important metric for this sector. It is essentially self-hedged against rising energy prices.

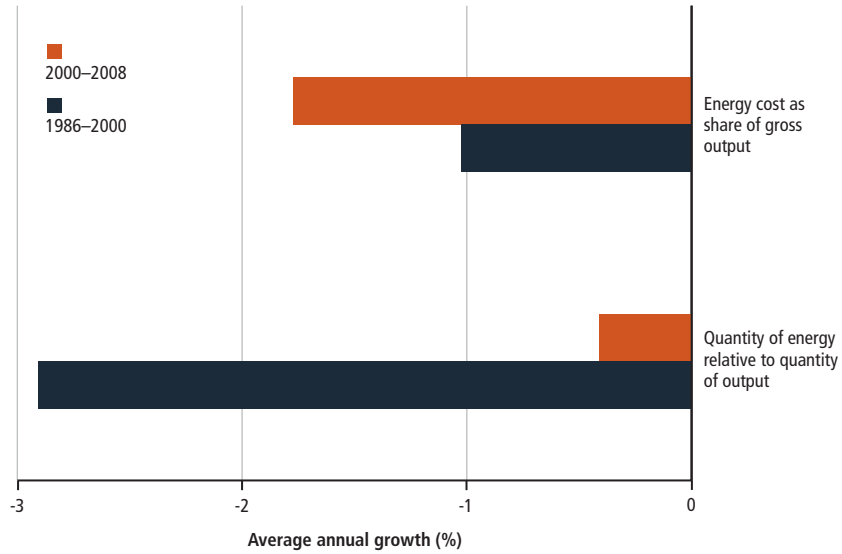
However, energy use is important in some parts of this sector, particularly for firms linked to the oil sands. One of the main processes used to extract bitumen from the earth involves generating steam by burning natural gas. Furthermore, upgrading of the bitumen so that it can be processed by refineries also involves large quantities of natural gas. As such, a lower price of natural gas relative to oil would likely help these firms.

4.5.5 Capital-Intensive Mining Sector

The mining sector includes mining of all types of materials including coal, iron ore, uranium, copper, nickel, and zinc, as well as non-metallic minerals such as diamonds, potash, stone, limestone, and sand. The 21 plants with 500 or more employees are evenly distributed across Canada with 6 in Ontario, 5 in British Columbia, and at least 1 plant in every other province or territory except Nova Scotia, Yukon, and Nunavut (Industry Canada, 2014b).

The sector benefitted as prices for its products rose in parallel with those of energy. As such, the cost of energy as a share of the value of output is not a meaningful indicator for this time period (1986–2008). However, the data on the quantity of energy used in proportion to the quantity of output suggest that the improvement in energy use slowed down as energy prices rose (see Figure 4.12). Such a slowdown may have occurred because more energy-intensive mining methods were used or because mines were more distant from transport

infrastructure. The results of the Panel's survey discussed in Chapter 6 suggest that the mining sector is concerned about energy prices, perhaps because the recession reduced the correlation between mineral and energy prices.



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.12

Mining: Average Annual Change in Energy Intensity, 1986–2008

Energy cost as a share of the value of gross output declined in the mining sector. However, this occurred in a period when the price of mining products increased in tandem with the price of energy. The quantity of energy used per unit of production declined, but at a slower pace than in the previous period.

4.5.6 Capital-Intensive Electric Power Sector

The sector includes producers of primary energy from hydroelectric sources, other renewables and uranium, as well as producers of secondary energy from wood and fossil fuels such as coal and natural gas. It also includes those involved in the bulk transmission and distribution to individual users. It is exposed to energy prices both for the price of its output and of its input, although in most provinces output prices are regulated in a way that permits utilities to pass input price increases to customers. Because investment and employment kept pace with output growth, there was no productivity improvement in this

sector.[29] Nevertheless, the advance of technology would suggest that there is no inherent reason why productivity growth would be low in this sector (Conway & Nicoletti, 2007). Since the sector is influenced by government decisions and its capital equipment is long lived, it may not always react to changing prices of primary energy sources.

4.5.7 Other Capital-Intensive Sector

Waste and remediation services and pipeline transportation services were identified as industries exposed to energy prices because of their capital intensity and their links with energy markets.

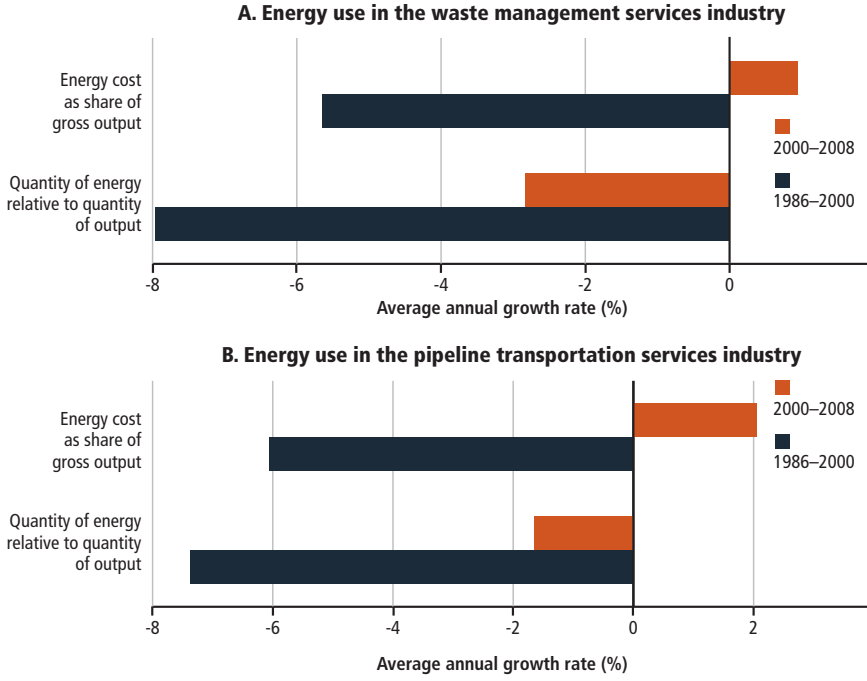
Waste and Remediation Services

The waste and remediation services industry includes waste collection, treatment and disposal, remediation services, and material recovery. The 4,623 establishments in Canada are distributed roughly according to provincial populations with 29% of them in Ontario. Only two plants employ more than 500 people, one in Manitoba and the other in Ontario (Industry Canada, 2014b). Although not traditionally linked to energy markets, as it is not as energy intensive as the sectors outlined above, the industry could benefit from increased global interest in transforming waste into energy. Panel A of Figure 4.13 shows that although the pace of its energy efficiency improvement was high in the 2000–2008 period, this rate had slowed compared with the pre-2000 period.

Pipeline Transportation Services

Pipeline transportation services involves transportation of crude oil, refined petroleum products, and natural gas sent to processing or storage facilities (excludes distribution to end consumers). Energy is required for compression and pumping, but the industry is not itself energy intensive. Demand for the products it carries and investment in new capacity would be tied closely with energy demand. Services supplied by this industry are generally regulated; pipelines crossing provincial or international borders are regulated by the National Energy Board, for instance. Traditionally, the industry is regulated based on cost of service where pipeline operators recover costs through the regulator every year. The regulator balances the needs of pipeline operators to recover their operating and investment costs against ensuring that rates are reasonable for its customers (NEB, 2013). In this respect, pipeline operators are at least partially insulated against energy price increases. The pace of improvement in energy efficiency slowed down in this industry after 2000 despite higher costs (Panel B, Figure 4.13).

29 Using Statistics Canada data (2014g), the Panel estimated that average annual productivity growth in this sector was 0.3% since 2000.



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.13

Waste Management Services and Pipeline Transportation Services: Average Annual Changes in Energy Intensity, 1986–2008

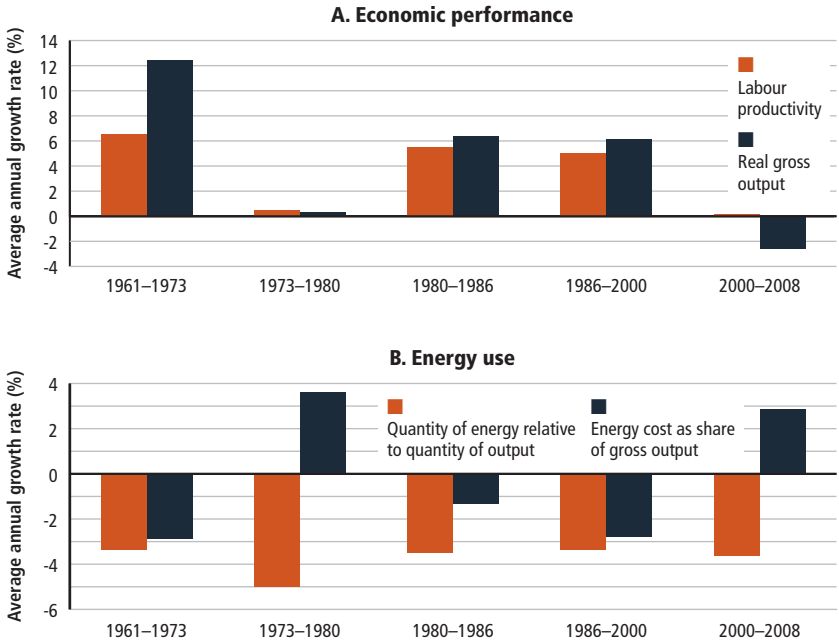
Both the waste management and pipeline transportation services industries are capital intensive, but they are also closely associated with energy markets. Both industries reduced their use of energy, but the pace of decline decelerated after 2000.

4.5.8 Transport Equipment Sector

This sector includes the manufacturing of equipment for all modes of transport including motor vehicles, trucks, parts, aerospace products, railroad equipment, and ships. It is a significant sector in Canada, directly employing around 1.5 million people. Of the 300 plants in Canada with 500 or more employees, 142 are in Ontario, 87 in Quebec, 17 in Manitoba, 16 in British Columbia, and 15 in Alberta (Industry Canada, 2014b).

The data suggest that this sector finds it relatively straightforward to deal with higher energy prices on the input side. The quantity of energy used in proportion to output declined steadily (Panel B, Figure 4.14). However, it can be challenging for the sector when energy prices change because the demand for its products is sensitive to the price of energy.

For the transport equipment sector in Canada, the periods of higher energy prices from 1973 to 1980 and from 2000 to 2008 coincided with periods of weak growth in both output and productivity (Panel A, Figure 4.14). Rising or volatile energy prices during these periods may have disrupted the sector as demand patterns changed across types of equipment. Adverse impacts on equipment manufacturing might be more noticeable for vehicles produced



Data Source: Panel calculations based on Statistics Canada (2014g)

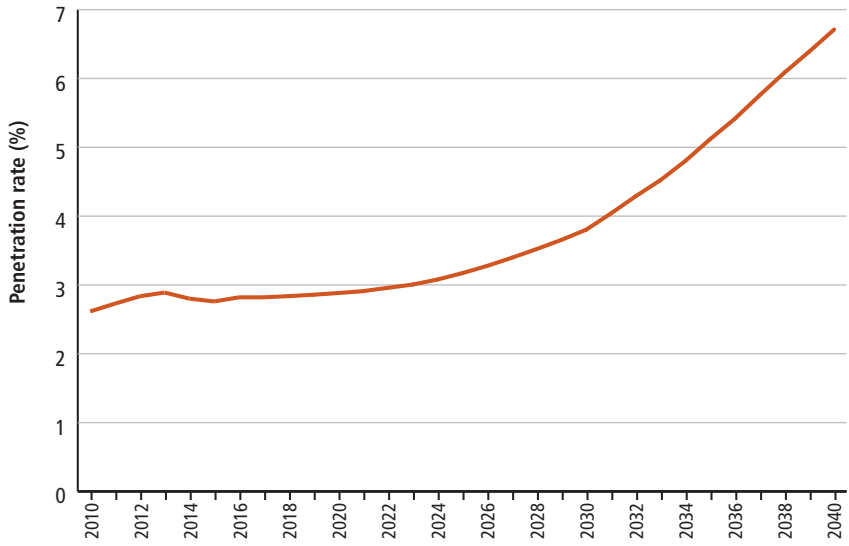
Figure 4.14

Transportation Equipment Manufacturing: Average Annual Growth Rates in Energy Intensity, Output, and Productivity, 1961–2008

The transport equipment sector (which includes production of motor vehicles and parts, buses, trucks, and aircraft) is affected by energy prices through demand for its product. During periods of increasing energy prices, such as in the 1970s and after 2000, the industry has faced static or falling productivity and gross output. Because of the range of component industries within this sector, the impact of energy prices will differ across them.

by U.S. firms (but typically produced in Canada), which had been less fuel efficient. Fukunaga *et al.* (2011) found that oil-specific demand shocks over the 1973–2008 period acted as positive demand shocks for many industries in Japan, in contrast to the experience in the United States where they acted as negative demand shocks. In other words, higher oil prices increased global demand for energy-efficient Japanese cars at the expense of less energy-efficient vehicles produced by North American manufacturers.

Despite the challenges that the sector has faced with rising oil prices in the past, it may be able to produce more energy-efficient vehicles or to produce vehicles that use natural gas in the future. The EIA (2013a) suggests that the penetration rate for natural gas vehicles will increase in the future (see Figure 4.15). Indeed, Canadian firms continue to develop technologies to enable trucks to change to natural gas.



Data Source: Panel calculations based on EIA (2013a)

Figure 4.15

The EIA Projected Penetration Rate of Natural Gas in Transport, 2010–2040

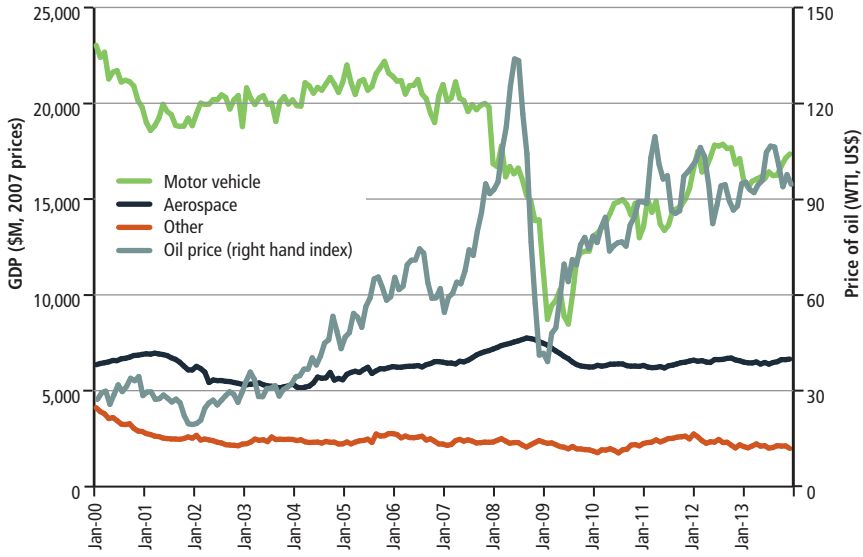
Increased supply of natural gas in North America will lower its price, and thereby create incentives to develop technologies that make intensive use of it. However, the EIA does not envisage a marked increase in the penetration of natural gas in transportation until after 2025. The penetration rate is the share of pipeline fuel, and compressed and liquefied natural gas in transportation.

The Panel identified the transport equipment sector as exposed to energy prices as a result of its review of empirical economics literature based on U.S. evidence (Section 3.3). Demand for automobiles may decline if the price of gasoline or diesel increases, or if there is a shift to more energy-efficient models. However, the transport equipment sector consists of many different types of industries, including those producing aircraft ships and trains. The composition of this sector may also vary across countries.

Figure 4.16 highlights several aspects of the sector that make its analysis complex. In Canada, motor vehicle production (including parts) accounts for 70% of the sector, aerospace for about 20%, and other transport equipment (railroad and ships) for the remainder (Statistics Canada, 2014h). The economic dynamics towards the end of the last decade were complex. The price of oil (and other commodities) had been rising steadily throughout the decade, but started to accelerate in early 2007, and the sector's GDP started a rapid decline at the end of the year. The economy also felt the full force of the financial meltdown when Lehman Brothers Holdings Inc. collapsed in September 2008. Identifying causal relationships has been challenging for economists. For example, it is difficult to confirm whether the rapid increase in the price of oil led to the slowdown in auto manufacturing, or whether consumers started anticipating the recession and held back their purchases. However, the timing would suggest that the rise in oil prices was affecting motor vehicle manufacturing adversely.

Demand for products is also affected by income levels, and may work in a direction opposite to the effect of prices. After the recession, both incomes and the price of oil grew in tandem as the motor vehicle manufacturing industry recovered. This trend suggests that the income effect was stronger than the price effect in this period whereas the price effect may have been dominant in 2007.

The data appear to be consistent with shocks to energy prices having the most impact on vehicle manufacturing, and less so on other parts of the transport equipment sector. As such, the Panel modified its earlier identification of the entire transport equipment sector as important to understanding the propagation of energy prices shocks, and restricted it to the motor vehicle manufacturing industry only. Unfortunately, the data available to the Panel to identify sectors exposed to energy prices did not include an aggregation as fine as the motor vehicle manufacturing industry.



Data Source: Panel calculations based on Statistics Canada (2014g) and EIA (2013a)

Figure 4.16

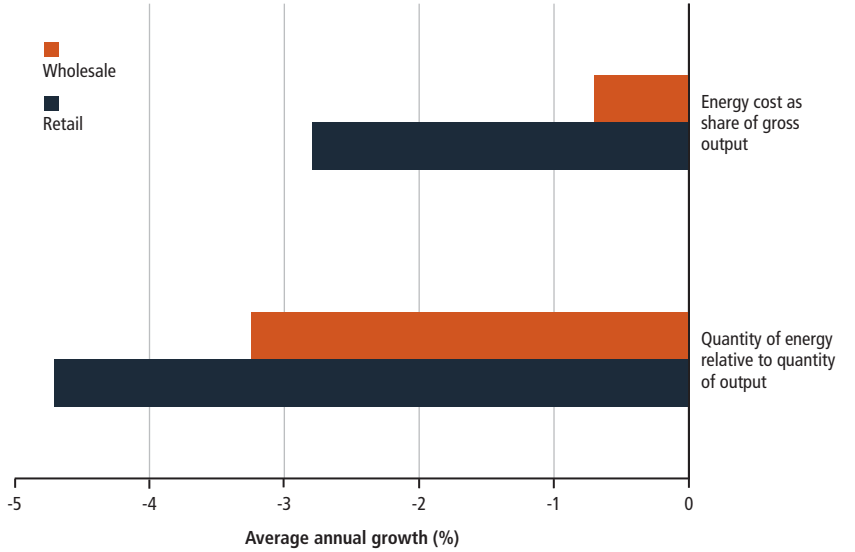
Value Added in Transport Equipment, and the Price of Oil, 2000–2013

The transport equipment sector includes production of motor vehicles, aerospace, and other (rail and ships). The rise in oil prices was closely associated with a decline in the value added of the motor vehicle manufacturing industry but had a smaller impact on the other industries. This pattern suggests that energy prices have different effects across the component industries of the transport equipment sector. Oil price is WTI.

4.5.9 Other Services and Other Manufacturing Sectors

The other manufacturing sector was included in the Panel's survey as a proxy for firms that are not energy intensive, but may be exposed to international competition. Since it encompasses such a broad collection of firms, no statistics are produced for it.

The other services sector includes both wholesale and retail trade industries. This sector was examined by the Panel as a proxy for the impact of energy on owners and operators of buildings. Clearly, there will be no direct competitiveness impacts on the sector in terms of lost market share to international competitors solely as a result of higher energy prices. Figure 4.17 suggests that the sector was able to improve its energy efficiency over time.



Data Source: Panel calculations based on Statistics Canada (2014g)

Figure 4.17

Wholesale and Retail Trade Services: Average Annual Change in Energy Intensity, 2000–2008

The wholesale and retail trade industries are not intensive users of energy. As energy prices rose, both industries reduced their use of energy markedly.

4.6 ADDITIONAL DATA NEEDED TO EVALUATE RESILIENCE

This chapter has demonstrated the sizeable adjustment made by many sectors in Canada after 2000 in response to higher and more volatile energy prices. The sectors that the Panel identified as being exposed to energy prices demonstrated their resilience by adjusting to price changes. However, due to differences in methodologies across countries, there are no international data that allow sectoral analysis of whether these adjustments were either significant or sufficient. Determining this capacity to adapt is challenging. At first glance, a high level of energy intensity in a Canadian industry relative to other countries may indicate a risk if energy prices increase. It may well be, however, that a high degree of energy intensity reflects lower energy prices in Canada. In this respect, it may be less costly for Canadian firms to improve their energy efficiency by investing in the more energy-efficient equipment already adopted in other countries.

In this respect, further analysis based on these approaches would be extremely useful. Although significant amounts of data are produced by Statistics Canada on energy use in physical terms, the development of timely economic data on the following would be particularly useful:

- **Cost and quantity of energy used by industry:** Energy must be defined consistently across countries, excluding energy sources when used as feedstock or material inputs to production.
- **Nominal value added or gross output by industry:** Since energy costs are reported in nominal terms, they need to be compared with nominal values of industrial output or value added. Timely indicators of pressures would examine the cost of energy as a proportion of the value of gross output.
- **Data at a finer level of disaggregation:** Since industries in a sector can react in measurably different ways to energy price shocks, finer data are needed (e.g., component industries of the transport equipment sector).

Armed with these data, researchers could better evaluate the different reactions across countries as price shocks hit the economy. Firms and countries that were more successful at adjustment would see, over the medium term, less decline in output, facilitated perhaps by increased investment and employment.

Detailed research based on plant-level data would also enable the impacts of energy prices to be captured. Such plant-level data are now becoming available from Statistics Canada for accredited academic and government researchers through the Canadian Centre for Data Development and Economic Research (Statistics Canada, 2014i). Plant-level data from the Annual Survey of Manufactures would allow, for example, the path by which increases in the price of energy fed through the economy to be examined, such as proportion of plants closing, and the reallocation of investment to more energy-efficient plants.

In addition, an important means of adapting to energy price shocks may be for firms to invest in relevant R&D. Therefore, opportunities from higher energy prices could be created for Canadian firms through this channel, as discussed in Chapter 3. However, since the intended uses of R&D are not currently captured in R&D data in Canada (CCA, 2013c), researchers are not able to assess how much R&D occurs as a result of energy price changes.

4.7 CONCLUSION

On the whole, the evidence reflects a significant amount of adjustment, at the sectoral level in Canada, to past changes and volatility in energy prices, most notably to oil price shocks. This suggests that Canadian sectors have been generally resilient to energy price changes. However, the lack of internationally comparable data based on common sectors and methodologies makes it difficult to compare the resilience of Canadian firms with firms in other countries.

The Panel's methodology identified several industries as facing challenges during a time of rising energy prices. A deeper examination of their performance has revealed that energy prices were, in general, not the proximate cause of these industries' struggles. Nevertheless, the changing pattern of oil prices relative to natural gas prices played a large part in the challenge confronting the chemical manufacturing industry. This pattern has reversed and this industry can benefit significantly if gas prices remain relatively low. The paper manufacturing industry, which has faced more significant technological changes such as digitization, has also responded by limiting its energy use and switching away from oil-based products. It now has opportunities in fields of biochemical and advanced materials. The motor vehicle manufacturing component of the transport equipment sector has had to deal with excess capacity in North America, which may be linked to changing demand patterns among vehicles. Again, however, new opportunities are arising in this industry through developing equipment to power transport based on natural gas and electricity.

While the methodology developed proved its worth, the Panel's work would have been further enhanced by the availability of internationally comparable data on energy used, in physical units and costs, on a methodologically comparable basis across industries.

This past resilience of Canadian sectors, however, does not guarantee such resilience in the future because energy markets, as described in Chapter 2, are becoming increasingly complex as a result of technological change and the increased availability of natural gas. Thus, in Chapters 5 and 6, in its reporting and analysis of its business survey results, the Panel explores the management practices of Canadian firms in the face of changing energy prices, and their preparedness for such change.

5

Behaviour of Canadian Firms in the Energy Context: Survey Results

- Survey Methodology
- Characteristics of Survey Respondents
- Past Responses to Changing Energy Markets
- Access to Specialized Skills and Knowledge Related to Energy Prices
- Conclusion

5 Behaviour of Canadian Firms in the Energy Context: Survey Results

Key Findings

- A large proportion of the Canadian firms surveyed have experienced price changes over the past five years and reacted and adapted in response to these changes. To maintain their competitiveness, three-quarters of firms acted to control energy costs, mostly by investing in new energy-efficient equipment.
- Energy costs were very or extremely important to the competitiveness of two-thirds of firms surveyed.
- According to the survey, 22% of firms employed a person who undertook financial or economic analysis of energy prices, and 16% employed a person who undertook technical analysis related to energy use.
- Firms rely on a wide variety of sources to get information on energy prices, with 18% of firms surveyed having information that allows them to benchmark against their competitors.
- Large differences exist across firms in the availability of specialized staff, market information, and benchmarking data on competitors.
- Without data from other sources, especially similar surveys undertaken in other countries, it is difficult to determine the full implications of the Panel's survey results.

In addressing its charge, the Panel was aware that it would not be able to rely on theoretical or statistical analysis alone. As well, there were no readily available data on some of the issues key to the charge. The Panel therefore commissioned a specialized survey of just over 1,000 firms in Canada to explore the strategies and incentives for management decisions and behaviours in relation to changing energy prices. Questions were largely designed around the Panel's analysis of the management literature in Chapter 3. The Panel views the survey as complementary to the theoretical analysis, industry-level statistics, and individual examples of industry behaviour discussed in previous chapters. The survey captures a rich picture of firms' efforts to maintain their competitiveness in the face of higher and more volatile energy prices.

This chapter reviews the design and structure of the survey, and some of the factors to be considered in interpreting the results. It also presents some high-level results on past responses of firms to energy price increases and the availability of specialized staff and access to information on energy markets and

benchmarking data. These results are analyzed on a sectoral basis in Chapter 6. Where appropriate, the Panel considers how survey results are consistent with, or diverge from, the evidence and findings presented in earlier chapters, and explores the implications of these comparisons.

5.1 SURVEY METHODOLOGY

In May 2013, on behalf of the Panel, EKOS Research Associates surveyed 1,008 firms on management views and responses to changing energy markets. The survey questionnaire (reproduced in the Appendix), which was based primarily on the evidence reviewed in Chapter 3, was designed to be answered in a telephone interview lasting 15 minutes or less. Interviewers navigated their way through firms to reach the most senior decision-makers with knowledge of the firm's energy-related issues. Typically, interviewers reached the chief executive officer or chief operating officer. Table 5.1 shows the main job titles of individuals who responded to the survey, as reported by respondents.

Table 5.1
Job Titles of Respondents to Survey

	Share of all survey respondents (%)
President/Chief executive officer	23
Owner or part owner	13
Department manager	9
Chairman	8
Controller or comptroller	7
Department director	6
Administrator	6
Branch or operations manager	5

Source: Panel survey data

The table shows job titles of those who represented 5% or more of survey respondents.

The firms surveyed were from the 10 sectors identified by the Panel in Chapter 3, which were based on NAICS codes. In creating the sample, the list of firms to be surveyed was supplied to EKOS by a sample firm (SM Research) based on those NAICS codes. Quotas were set in the sample based on the size and sector of firms, and a random sample of firms from the sample was surveyed. The response rate to the survey was 5.4%, which is fairly typical of a survey of this type.

The survey was structured as follows:

- characteristics of the business, such as the number of employees (questions 1 to 5);
- elements that can influence firm decision-making related to changes in energy price, such as the share of energy cost in operating costs (questions 7 to 11);
- experiences of firms in adjusting to energy price increases and volatility in the past (questions 12 to 20);
- technical changes that firms expect to take in response to energy price changes (questions 21 to 26);
- experiences of firms with regulations and policies, and whether these were helpful in adjusting behaviour or imposed constraints on behaviour (questions 27 to 34); and
- how firms expect to respond to price scenarios (questions 35 and 36).

When interpreting survey results, certain caveats should be borne in mind. First, an important goal in conducting the survey was to get an adequate number of responses from each of the 10 sectors identified in Chapter 3. The Panel aimed at 100 firms (observations) for each sector, and was generally successful. However, it proved challenging to obtain a satisfactory number of observations for the capital-intensive sectors, particularly oil and gas (33 respondents) and electric power (43 respondents) (see Table 5.2). The survey results should not, therefore, be interpreted as fully representative of sector behaviour, but rather as findings of interest in identifying potentially important issues to pursue in greater depth.

Second, since the Panel was focused on information on firm energy use, the sectors, by definition, were not chosen to be representative of the entire Canadian business community. The Panel believes that its targeted sectoral approach to the questions is more relevant than a broad attempt to survey all industries in Canada. The presentation of the unweighted information by sector (in Chapter 6) provides a rich base for further investigation.[30]

Finally, aware of the difficulty in eliciting accurate commercially sensitive information from firms, the Panel was careful to analyze the survey results in conjunction with the theoretical and statistical considerations outlined in previous chapters.

30 The Panel discussed whether weighting should be applied to the sectoral results to permit generalizations about the Canadian business sector, but decided against such weighting.

Table 5.2
Number of Firms Surveyed and Distribution Across Sectors

Sector	Number of firms surveyed	Share of total survey (%)
Energy-intensive: resource-based	113	11
Energy-intensive: manufacturing	132	13
Energy-intensive: transportation services	143	14
Capital-intensive: oil and gas extraction	33	3
Capital-intensive: mining	60	6
Capital-intensive: electric power	43	4
Capital-intensive: other	105	10
Transportation equipment manufacturing	111	11
Other manufacturing	135	13
Other services	133	13
Total	1,008	100

Source: Panel survey data

5.2 CHARACTERISTICS OF SURVEY RESPONDENTS

This section summarizes the characteristics of the firms surveyed and, where relevant, compares them with Canadian averages to determine the representativeness of the sample. The Panel concluded that the survey represented an appropriate sample of firms exposed to energy prices in Canada, and that those firms had a wide variety of characteristics and experiences. As such, the survey could yield insights into the strategies and incentives for firms in responding to changes in energy prices. However, important nuances would need to be borne in mind when interpreting the survey, such as the types of fuel used.

5.2.1 Provincial Distribution

Since many firms operate across provincial boundaries, firms were identified in the survey from the telephone area code of the location of the senior manager who responded to the survey. This is normally the firm's headquarters, and not necessarily the location of an operating plant. As such, comparison of the characteristics of survey participants with general population characteristics is more appropriate at a national rather than a provincial level. Nevertheless, a broad distribution of responses from firms headquartered across the country was obtained, as shown in Table 5.3. The higher proportion of firms in Quebec

and Ontario reflects both the level of economic activity and the survey design, in which energy users were targeted. In addition, 5% of respondents said that their ultimate corporate headquarters were located outside of Canada.

Table 5.3
Distribution of Responses to Survey, by Province

	Share of responses (%)
Newfoundland and Labrador	1
Nova Scotia and Prince Edward Island	2
New Brunswick	1
Quebec	40
Ontario	30
Manitoba	3
Saskatchewan	3
Alberta	10
British Columbia	9
Territories	1
Total	100

Source: Panel survey data

The province of respondents was determined by telephone area codes. Since Nova Scotia and Prince Edward Island share an area code, they are grouped together in the table.

5.2.2 Energy Intensity

The Panel sought to determine if the survey successfully captured the differences in the energy intensities of the 10 sectors, as first outlined in Section 3.3. Table 5.4 compares the importance of energy in sectors selected by the Panel based on survey results (on the left), and in national Statistics Canada data (on the right), as shown in Table 4.1. The first two data columns reflect responses to a survey question on the share of energy costs in total operating costs, and the third column presents the response rate for this question. The final data column shows the cost of energy as a share of gross output by detailed NAICS industry according to Statistics Canada data. Given that operating costs are generally smaller than gross output (which approximates to sales), the responses to the survey question on energy cost as a share of operating cost would be expected to be higher than the Statistics Canada estimate of energy intensity. This is indeed the case.

In general, the ranking of energy intensities in the Panel's chosen sectors matches the ranking of energy intensities according to Statistics Canada data. It is worth noting that there was no reported significant difference in the energy intensities of the three manufacturing sectors included in the Panel's survey (the energy-intensive, transport equipment, and other manufacturing sectors). Energy costs are a much higher share of operating costs for survey respondents from the oil and gas sector than in the NAICS industries. Such differences may arise from many sources, such as (i) differences in interpreting whether a fuel is used as an energy source or as a raw material to be processed and (ii) compositional differences in that the survey results present equally weighted firms regardless of size, while Statistics Canada values implicitly use economic weights.

A further possibility is that firms particularly concerned about energy were more likely to respond to the survey. In this respect, there may be a sample-selection bias in the survey responses. There is no easy way of testing whether this concern is valid. If the bias does exist, however, it would mean that the survey has captured responses of firms that were particularly exposed to or otherwise interested in energy prices, which would be consistent with the Panel's focus and charge.

Table 5.4

Energy Intensity Characteristics of Sectors in the Survey and in Canada

Sectors chosen by Panel and responses from survey				NAICS classifications and Statistics Canada data	
Panel sector name	Approximately what proportion of your operating costs are energy costs?		Share of firms in sector responding to question	NAICS industry names	Energy costs as a share of gross output in 2008 (%)
	Mean (%)	Median (%)			
Energy-intensive: resource-based	24	20	86	Crop and animal production Forestry and logging Fishing, hunting and trapping	7 7 16
Energy-intensive: manufacturing	14	10	82	Paper manufacturing Chemical manufacturing Non-metallic mineral product manufacturing Primary metal manufacturing	10 15 8 7

continued on next page

Sectors chosen by Panel and responses from survey				NAICS classifications and Statistics Canada data	
Panel sector name	Approximately what proportion of your operating costs are energy costs?		Share of firms in sector responding to question	NAICS industry names	Energy costs as a share of gross output in 2008 (%)
	Mean (%)	Median (%)			
Energy-intensive: transportation services	32	30	89	Air, rail, water and scenic and sightseeing transportation and support activities for transportation Truck transportation Transit and ground passenger transportation	18 18 13
Capital-intensive: oil and gas extraction	36	20	79	Oil and gas extraction	2
Capital-intensive: mining	25	20	83	Mining (except oil and gas)	7
Capital-intensive: electric power	16	5	74	Electric power generation, transmission, and distribution	14
Capital-intensive: other	20	15	85	Pipeline transportation Waste and remediation services	5 8
Transport equipment	16	7	84	Transportation equipment manufacturing	1
Other manufacturing	15	10	83	Wood product manufacturing Petroleum and coal products manufacturing Plastics and rubber products manufacturing Fabricated metal product manufacturing Machinery manufacturing Computer and electronic product manufacturing	3 4 3 2 1 1
Other services	14	7	76	Wholesale trade Retail trade	4 4
Survey average	20	15	83		

Data Source: Panel calculations based on Statistics Canada (2014g) and Panel survey data (Q8)

5.2.3 Firm Size

Following Statistics Canada's classification of firm sizes, Table 5.5 compares firm sizes in the survey with business registry data. Of surveyed firms, 17.9% were of medium or large size compared with 1.9% in the overall Canadian business sector. As such, the survey had a higher representation of large firms than in the Canadian economy.[31]

Table 5.5

Distribution of Firms by Employment Category, Survey and Canada

Distribution of responses by firm size			
Number of employees	Firm size category	Survey, 2013 (%)	Canada, 2012 (%)
0–4	Micro	32.3	54.9
5–99	Small	47.3	43.2
100–499	Medium	13.3	1.7
500+	Large	4.6	0.2
Don't know		2.5	
Total		100.0	100.0

Data Source: Panel survey data (Q6) and Industry Canada (2012)

The Industry Canada data include all of the Canadian economy, including sectors that were not covered by the Panel's survey.

5.2.4 Exposure to Energy Prices

The Panel's survey captured a fair amount of heterogeneity in the use of energy. In its analysis of sectors exposed to energy prices in Chapter 3, the Panel identified several channels through which energy prices can have an impact on firms. Higher energy prices can increase firms' costs directly, increase costs of other goods they purchase, or alter the demand for the goods and services they produce. Survey respondents were asked to identify themselves according to these categories (see Table 5.6). Sectors producing energy were more likely to say that energy prices affected demand for their products. At least three-quarters of firms in other sectors said that energy would have an impact through higher costs. Of these firms (whether affected by energy directly or by other energy-intensive purchased inputs), 43% said the main use of energy was for the operation of equipment, 30% for transportation, 20% for heat and light, and 2% for feedstock.

31 Survey responses could be correlated with a number of sector characteristics. In general, the Panel concentrated on reporting results by firm size, as this was correlated with other variables such as the proportion of sales exported and the age of the firm.

Because its products are complements to energy and, therefore, demand for them could be altered by higher energy prices, the transport equipment sector was identified separately by the Panel as exposed to energy prices. However, only 14% of firms surveyed in this sector identified this channel as the most important influence of energy prices. Several possibilities could account for this outcome, including that the Panel's earlier hypothesis is false (i.e., the transport equipment sector is *not* central to understanding the impact of energy prices because of the impact of energy prices on the demand for its products).

Table 5.6

Energy Price Channels Most Affecting Firms in the Survey

	Do energy costs mostly impact your firm through higher direct energy purchase costs, higher costs of other purchased inputs, or a change in demand for your products or services?		
Sector	Higher direct energy purchase costs (%)	Higher costs of other purchased inputs (%)	Change in demand for your products or services (%)
Energy-intensive: resource-based	74	20	6
Energy-intensive: manufacturing	73	13	14
Energy-intensive: transportation services	81	8	11
Capital-intensive: oil and gas extraction	49	15	36
Capital-intensive: mining	83	7	10
Capital-intensive: electric power	57	21	21
Capital-intensive: other	75	11	14
Transportation equipment	73	14	14
Other manufacturing	65	20	15
Other services	68	17	15
All sectors	72	15	14

Source: Panel survey data (Q11)

Number of don't knows: 1

An alternative interpretation, however, is that only parts of the transport equipment sector are exposed to energy price changes, notably those industries linked to manufacturing automobiles. The data presented in Section 4.5.8 showed that other industries, such as aerospace and railroad equipment manufacturing, were not as affected by energy price changes as automobile manufacturing. However, survey responses are too broad to capture the impact of energy prices solely on automobile manufacturing because the sample included firms across all sub-industries of the transport equipment sector.

5.2.5 Fuel Use

Given the many forms of energy that can be purchased and used, survey respondents were also asked which fuel affected their operations the most. The most common answers were oil products or electricity (see Table 5.7). Beyond the manufacturing and electric power sectors, there are few national-level data on fuel types used according to the NAICS classifications. However, the proportion of the surveyed firms using oil is likely to be higher than the Canadian average, notably because of the high number of transportation service firms in the survey.

Looking within sectors, firms using natural gas may be underrepresented in the survey. Data presented in Section 4.5.2 indicate that around 60% of the manufacturing sector in Canada uses electricity or gas, with the share of each fuel roughly evenly divided. By contrast, only 9% of survey respondents identified natural gas as the fuel source with the greatest impact on them.

As shown in Table 5.8, most firms surveyed had experienced energy price increases over the previous five years, including 77% of those consuming oil-based products (e.g., diesel, gasoline), 58% of those using electricity, and 42% of those using natural gas. On average, those affected by natural gas had seen their energy prices stay the same or fall, while those whose business is mostly affected by oil products had very likely seen their energy prices rise.

Table 5.7

Fuel Use by Sector in the Survey

Sector	Which of the following energy sources has the greatest impact on your operations?		
	Oil products (%)	Natural gas (%)	Electricity (%)
Energy-intensive: resource-based	67	6	27
Energy-intensive: manufacturing	27	10	64
Energy-intensive: transportation services	83	1	16
Capital-intensive: oil & gas extraction	52	21	27
Capital-intensive: mining	60	10	30
Capital-intensive: electric power	**23**	12	65
Capital-intensive: other	**65**	11	24
Transportation equipment manufacturing	**32**	5	64
Other manufacturing	**28**	10	62
Other services	**28**	11	61
All sectors	**47**	9	45

Source: Panel survey data (Q10)

Number of don't knows: 0

Table 5.8

Firms More Likely to Have Seen Price Rises by Fuel Source

As a share of operating costs, have your energy costs fallen, risen or stayed about the same over the past five years?	Which of the following energy sources has the greatest impact on your operations?			Share of total number of firms in survey (%)
	Oil products (%)	Natural gas (%)	Electricity (%)	
Fallen	3	13	6	5
Risen	77	42	58	66
Stayed about the same	17	40	33	26
Don't know/No response	3	6	4	3

Source: Panel survey data (Q9 and Q10)

5.3 PAST RESPONSES TO CHANGING ENERGY MARKETS

This section reviews whether or not firms had responded to past changes in energy prices, the changes made if they had responded, and the motivation for the changes (see Section 6.1.1 for a breakdown and analysis of these results by sector). In general, the survey revealed that firms in Canada had reacted to maintain their competitiveness, mostly by investing in energy-efficient equipment.

Nearly three-quarters of firms surveyed had made a technical change in the previous five years to manage energy costs. The majority (59%) had done so by investing in energy-efficient equipment, 23% had changed suppliers, 15% had switched fuels, 8% had relocated, and 5% had done "something else." When fuel switching is correlated with fuel use, 19% of firms currently using oil-based products had done some fuel switching, as had 19% of those using natural gas and 10% of those using electricity.

Given the distinction drawn in Chapter 3 between permanent price changes and short-term volatility, the survey also asked for reactions to price volatility. When asked how they had responded to the episodes of energy price volatility in 2008, 42% of firms said that they had changed strategy or operations in 2008.[32]

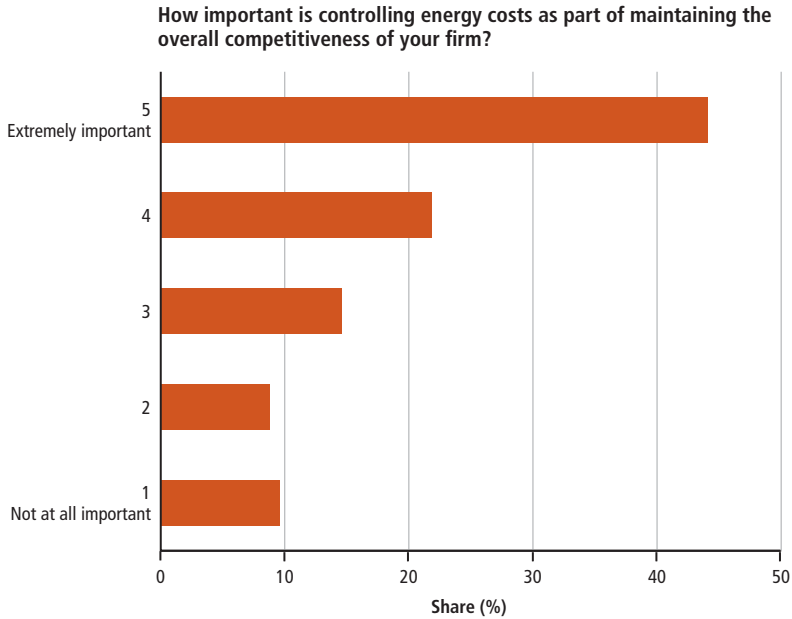
A wide range of reactions to volatile energy prices in 2008 were reported: 11% of firms invested in equipment, 7% raised prices, 13% changed processes, 8% changed suppliers, and 2% cut energy use. Consistent with the theory outlined in Chapter 3, firms were less likely to invest in new equipment in the face of short-term volatility than if there were permanent prices increases. Investment in equipment is more likely when price increases are seen as permanent. In general, larger firms were more likely to invest and to raise prices in response to volatility, whereas firms of all sizes were as likely to change processes. Firms that stated that natural gas was currently their most important source of energy were twice as likely (21%) as users of other fuels (8%) to have changed suppliers in 2008. These ratios indicate that some transition to the use of natural gas has taken place since 2010.

To better understand the importance that managers attach to the impact of energy prices on their business, and the motivation for their actions, the survey included a question on the impact of energy prices on the firm's competitiveness. Since competitiveness may be interpreted differently depending on the business context, no specific definition of competitiveness was given to respondents. For export-oriented manufacturing firms, for example, an impact on competitiveness

32 Results suggest that whether a firm changed strategy in response to events in 2008 related to firm size and energy costs rather than export intensity (exports as a proportion of sales).

could be reflected in losing market share in foreign markets while transportation services firms would not face international competition to the same extent. Instead, they could face higher input costs that are difficult to pass on to customers and would therefore squeeze profit margins.

A high proportion of respondents said that energy prices were important to them: 44% said that controlling energy costs was "extremely important" while 22% said energy prices were "very important" to their overall competitiveness (see Figure 5.1). These results reinforced the Panel's confidence that it had indeed identified and analyzed the sectors in Canada that are exposed to the evolution of energy prices (see Section 6.1.1 for a breakdown of these results by sector).



Source: Panel survey data (Q7)

Figure 5.1

Importance of Controlling Energy Costs to Maintaining Competitiveness

The figure shows survey respondents' assessment of how important controlling energy costs is to their competitiveness. Two-thirds of respondents said that energy was either extremely or very important to them.

Given the highly complex environment in which firms operate with many internal and external factors affecting operational decisions, the Panel sought to examine the extent to which firms would indeed respond to energy prices

in their own business interests. Firms that had undertaken a technical change in the past five years (nearly three-quarters of respondents) were asked why they had done so. Respondents were invited to use their own words to explain their motivation for such change, and these were then recoded into the categories presented in Table 5.9. Up to three responses were accepted from each respondent, as some firms may have been driven by several reasons.

Table 5.9

Motivation for Technical Changes in Last Five Years

What had motivated technical changes made in the prior 5 years?	Share of those who had made technical changes (%)	Share of all respondents to the survey (%)
Competitiveness	56	40
Changing energy prices	46	33
Replacement of obsolete or old equipment	16	12
Environmental or social responsibility	6	5
Government incentives or policy	5	4

Source: Panel survey data (Q25)

Respondents were allowed to provide up to three answers using their own words.

Of those firms that had made technical changes, 56% (or 40% of the entire sample of firms) had done so to maintain their overall competitiveness. Respondents used phrases such as "improving efficiency," "lowering costs," or "maintaining profit margins." Of those that had undertaken technical changes, 46% did so specifically in response to energy prices, 16% were replacing worn-out equipment, 6% did so to improve environmental performance, and 5% were reacting to either government incentives or regulations. In practice, there is considerable overlap between maintaining competitiveness and responding to energy prices. As might be expected from the literature review in Chapter 3, normal business behaviour of maintaining competitiveness and responding to energy prices were by far the most important motivation for a change in behaviour.

5.4 ACCESS TO SPECIALIZED SKILLS AND KNOWLEDGE RELATED TO ENERGY PRICES

As outlined in Chapter 3, the Panel was particularly interested in the potential strategies or management practices that firms might implement in the face of changing energy prices, such as the personnel and time dedicated to looking at energy issues and the information available to managers. This section presents the high-level survey results on indicators of these issues (see Section 6.3 for more detailed analysis and sectoral breakdown).

5.4.1 Personnel and Time

Respondents were asked whether they employed personnel dedicated to energy issues, including those looking at financial implications of energy prices and those looking at technical issues related to energy use. Of all firms surveyed, 22% had staff looking at financial aspects; 16% had staff looking at technical aspects; 71% had neither; only 10% had both; 6% had a technical specialist but not a financial analyst; and 11% had a financial analyst but not a technical specialist (see Table 5.10).

Table 5.10

Share of Survey Respondents with Dedicated Personnel for Energy Issues

	Proportion with employee whose job description includes:	
	Financial or economic analysis of energy prices (%)	Technical analysis related to energy use (%)
Yes	22	16
No	76	82
Don't know/No response	1	2

Source: Panel survey data (Q13 and Q21)

The amount of attention given by senior managers to energy issues varied widely across firms, with 4 in 10 respondents saying that senior management meetings rarely or never involved discussion of energy prices or costs, and a similar proportion saying that energy prices were often or always discussed (see Table 5.11).

Table 5.11

Attention of Senior Management to Energy Issues

How often are energy prices or costs discussed at meetings of senior management?	Share of firms (%)
Always	15
Often	23
Sometimes	22
Rarely	20
Never	17
Don't know/No response	3

Source: Panel survey data (Q14)

5.4.2 Information on Energy Price Markets and Benchmarking

The Panel was interested in how firms obtain information on the trajectory of energy prices, and in whether firms have access to information, such as benchmarking data, that would encourage them to improve the energy efficiency of their operations. The importance of accessing these types of information can be evaluated by examining the correlation between the availability of information and the readiness and ability to take appropriate decisions when circumstances change. Although the survey data are not robust enough to provide a strong test of this hypothesis, they do show a strong correlation between firms that took action in response to high and volatile prices in 2008 and firms that had relevant information available. This is reported in more detail in Chapter 6.

Energy Price Information

Effective management decisions require access to relevant information. As discussed in Section 3.2.3, the University of Calgary survey of Canadian business leaders found that they were not particularly well informed about energy in general, and had limited sources of information (Moore *et al.*, 2013). The Panel's survey went further by requesting greater detail on the sources of information, and linking information availability to business sectors (see Section 6.3). Up to three descriptions of responses were recorded for each respondent. These were then classified into the nine groups presented in Table 5.12. "Professional sources" include information obtained from banks, energy consultants, other consulting firms, professional publications and research, and directly from financial markets. One-half of respondents got at least some information from the news or the internet. This share is lower than reported by the University of Calgary study in which 65% of respondents got their information from television, general internet, national and local newspapers, websites, and radio (Moore *et al.*, 2013). Government and industry reports were the main source of information for 17% of respondents in that study, and there were no specific mentions of industry associations or professional sources.

Respondents to the Panel's survey (weighted towards those more likely to be affected by energy prices) are better informed than the general professional population surveyed in the University of Calgary study in that more respondents in that study said that the media were their main source of information (65% versus 50% of respondents to the Panel's survey). Furthermore, many respondents to the Panel's survey used multiple sources of information. Since managers in sectors more exposed to energy prices took steps to become better informed than the general professional population, it would seem that senior business managers do value such information. Nevertheless, some survey respondents made the definitive statement that there was no official source of information.

Table 5.12

Sources of Information on Energy Prices

Information Source	Share of Firms (%)
News and internet	50
Suppliers and customers	36
Internal	7
Government (domestic and international)	4
Professional sources	7
Industry associations	7
Common sense	2
Word of mouth	4
We don't make predictions about energy price changes	8
Don't know/No response	4

Source: Panel survey data (Q15)

The share indicates those firms that obtain information from that source. Firms could list up to three sources of information, and therefore the sum of shares is more than 100%.

A distinction can be drawn between information freely available versus information for which firms would expect to pay. This is a crude distinction, as some firms may pay for access to detailed internet data (beyond those available without subscription or membership fees). Furthermore, firms that pay for information may be more concerned about short-term volatility in prices than their long-term exposure: banks and financial markets tend to project energy prices for the next few quarters, for example. Firms in some sectors, such as transportation services, may only be concerned about the price they charge for transportation over the next few months, and therefore only interested in short-term energy price forecasts.

Government projections are likely to be free, but may involve a degree of awareness on the part of managers to know that these sources actually exist. To some extent, projections from government and professional sources are reflected in news reports and can be found on the internet. However, the mediation of the original analysis may affect the breadth of information that is taken into consideration by firms relying on these sources.

According to the survey, 7% of firms look to professional suppliers (such as banks and consulting firms) for information on energy. The tendency to get information from professional sources increases with firm size. Around 6% of firms with fewer than 100 employees (micro and small) obtain information from professional sources compared with 24% of firms with 500 or more employees. Of the 7% of firms that get their information from industry associations, one-quarter are in the transportation services industry. A number of respondents made specific reference to U.S. organizations, such as the EIA, as sources of information.

Benchmarking Information

Knowledge of the energy performance of competitors is valuable to understanding how well a firm is doing. Since barriers to access for such commercially sensitive information can be significant, it often needs to be mediated through industry associations or government. Table 5.13 shows that 18% of surveyed firms have access to benchmarking data, and 24% are aware of their competitors' actions to improve their energy efficiency.

Table 5.13

Share of Firms with Access to Information on Benchmarking and Competitors' Actions

	Do you have information that allows you to benchmark your energy efficiency against your competitors? (%)	Are you aware of energy efficiency measures taken by your main competitors? (%)
Yes	18	24
No	78	68
Don't know/No response	4	8

Source: Panel survey data (Q17 and Q19)

5.5 CONCLUSION

The survey successfully captured a broad sweep of firms exposed to energy prices and a diversity of experiences, thus yielding insights into the actions of senior decision-makers in the face of changing energy prices. A large proportion of firms surveyed had experienced price increases over the previous five years and had reacted to maintain or improve their competitive positions, in line with the theory outlined in Chapter 3 and the aggregate evidence presented in Chapter 4. To maintain their competitiveness, they had mainly reacted by investing in energy-efficient equipment.

According to the survey, there were significant differences across firms in the availability of specialized staff, market information, and benchmarking data on competitors. Without data from other sources, especially similar surveys undertaken in other countries, it is difficult to determine whether these numbers are high or low. However, with the increasing complexity of energy markets going forward, as outlined in Chapter 2, there will likely be increasing demand for information and skill resources to enable firms to reach better decisions about their business operations. Chapter 6 discusses these issues in more detail at the sectoral level, and analyzes them in the context of how "prepared" sectors are for the energy future.

6

Expected Impacts of Energy Price Changes on Canadian Firms: Sectoral Analysis of Survey Results

6 Expected Impacts of Energy Price Changes on Canadian Firms: Sectoral Analysis of Survey Results

Key Findings

- The mining, transportation services, and energy-intensive resource-based sectors are the most vulnerable to higher energy prices, along with sectors that consume oil-based products.
- Higher energy prices may create opportunities for the capital-intensive oil and gas and electric power sectors, as well as for those that produce energy-efficient equipment. Firms that can switch their energy use from petroleum-based products to natural gas may benefit from the decoupling of prices for different types of energy.
- Sectors that are exposed to energy prices — whether higher prices create opportunities for them or make them vulnerable — can increase their resilience or capacity to adjust to price changes by being prepared. Preparedness can be measured by firms' access to detailed information on energy markets, benchmarking data, and specialized personnel who understand the financial and technical implications of energy developments.
- The three indicators of preparedness are correlated with a history of taking action in response to higher and more volatile energy prices. For example, in response to price shocks in 2008, 60% of firms with benchmarking information took action, compared with 40% of firms without benchmarking information.
- Of the firms surveyed, 24% met the criteria for two of the three indicators of preparedness. The share varied by sector, ranging from a low of 13% in the other manufacturing sector to a high of 37% in the capital-intensive electric power sector.
- Levels of and approaches to preparedness follow roughly similar patterns across the most potentially vulnerable sectors, with gathering of detailed energy data the most common activity undertaken.

This chapter reviews and analyzes the results of the Panel's survey of Canadian firms by sector to assess the expected impacts of energy price changes to 2025. In exploring interactions of energy markets and sectors exposed to energy prices, the Panel evaluated (i) which sectors would be best equipped to deal with higher energy prices (i.e., those that would have opportunities) and (ii) which sectors would be challenged by price increases (i.e., those that could be potentially vulnerable). Where available and appropriate, the Panel's analysis of survey results draws in the theoretical and statistical considerations and evidence outlined in previous chapters.

Despite their exposure to energy prices, many sectors and firms can prepare themselves to capitalize on opportunities or counter their vulnerability in times of rising prices. To evaluate the degree of preparedness of Canadian sectors, the Panel developed three indicators based on questions asked to firms in the survey: the availability of dedicated and appropriate personnel for energy issues, adequate information about future energy price trends, and access to data that allow benchmarking against competitors. To gain a greater understanding of the role that such preparedness might play, the Panel then explored the correlation of the indicators of preparedness with firm behaviour. The survey results suggest that preparedness does in fact play a role in facilitating change by Canadian firms.

The first two sections focus on the financial and business impacts of changing energy prices by sector, highlighting potential vulnerabilities and opportunities. The third section discusses how prepared Canadian business sectors are to capitalize on opportunities and mitigate risks associated with higher energy prices.

6.1 IMPACTS OF CHANGING ENERGY PRICES ON SECTORS IN CANADA

This section presents a sectoral analysis of survey results of Canadian firms on the expected impacts of changing energy prices (when sample sizes are sufficiently large). It begins with a sectoral breakdown of past responses of firms in periods of higher energy prices, followed by the impact of prices on sectors and anticipated impacts and responses to higher and lower energy prices in the future.

6.1.1 Past Responses to Higher or Volatile Energy Prices

As noted in Section 5.3, nearly three-quarters of firms surveyed had made a technical change in the previous five years to manage energy costs. Of these, 59% had invested in equipment, a fairly uniform reaction across sectors apart from the oil and gas sector (see Table 6.1). The fact that many responded to increases in energy prices by investing in energy-efficient equipment sheds some light on where the opportunities may lie if energy prices rise. Firms that had not made any changes in the previous five years (26%) were more likely to have been in the oil and gas, electric power, transport equipment, and other services sectors. For the oil and gas and electric power sectors, the effect of energy prices on inputs was less likely to be as important as the impact on the level and value of output.

Table 6.1

Technical Changes Made by Firms over the Last Five Years to Manage Energy Costs, by Sector

	Proportion of firms in a sector, by response					
Sector	Switched fuels (%)	Invested in equipment (%)	Relocated (%)	Changed suppliers (%)	Other (%)	No adjustment (%)
Energy-intensive: resource-based	19	62	10	31	5	20
Energy-intensive: manufacturing	17	58	8	26	6	20
Energy-intensive: transportation services	20	62	8	29	6	22
Capital-intensive: oil and gas extraction	12	39	3	21	0	33
Capital-intensive: mining	22	58	7	37	3	23
Capital-intensive: electric	14	58	9	14	5	33
Capital-intensive: other	17	62	8	24	4	27
Transportation equipment manufacturing	9	59	9	18	5	32
Other manufacturing	13	60	8	19	7	24
Other services	9	59	8	11	4	32
All sectors	**15**	**59**	**8**	**23**	**5**	**26**

Source: Panel survey data (Q24)

Firms were asked if they had made a technical change in the previous five years to manage energy costs. If so, was it by switching fuels, investing in equipment, relocating, changing suppliers, or something else? Since up to three reactions were recorded, the sum of reactions may exceed 100%.

To compare responses in times of higher prices with those in times of price volatility, firms were also asked how they had responded to the energy price volatility in 2008. Of the 42% of firms that had changed strategy or operations in 2008 (recall Section 5.3), reactions were fairly similar across sectors, reaching a high of 52% of firms in the transportation services and other capital-intensive sectors (see Table 6.2).

Table 6.2

Changes in Strategy in Response to Volatility in 2008, by Sector

Sector	Did your firm make any changes in strategy or operations?		
	Yes (%)	No (%)	Don't know/ No response (%)
Energy-intensive: resource-based	45	50	5
Energy-intensive: manufacturing	42	54	4
Energy-intensive: transportation services	52	46	2
Capital-intensive: oil and gas extraction	50	50	0
Capital-intensive: mining	48	46	5
Capital-intensive: electric	22	65	14
Capital-intensive: other	52	46	2
Transportation equipment manufacturing	36	62	2
Other manufacturing	33	64	2
Other services	43	56	1
All sectors	42	54	3

Source: Panel survey data (Q12)

The sample size was restricted to firms that had been in existence for more than four years.

6.1.2 Expected Impacts of Higher or Lower Energy Prices in the Future

To gauge the impact of changing energy prices in the future, the survey asked about the likely impacts of hypothetically much higher or lower energy prices looking out to 2025. Results for the anticipated reactions to such price increases are shown in Table 6.3 and to price decreases in Table 6.4. The results suggest that the most adverse impacts from higher energy prices (in terms of closure and magnitude of impacts) were anticipated in the mining, transportation services, and energy-intensive resource-based sectors (over 20% of each sector). These sectors would, therefore, be vulnerable to higher energy prices. As expected, one of the sectors with the least anticipated impacts is the other services sector, one of the two sectors chosen because it was not exposed to energy prices. Firms in both the oil and gas and electric power sectors felt that they would generally benefit from higher energy prices in terms of higher profits.

The anticipated rate of plant closure or significant employment declines was highest in the energy-intensive resource-based, energy-intensive manufacturing, transport equipment, and capital-intensive mining sectors. The price of mining commodities has generally tracked energy over the last decade because both have

Table 6.3

Impacts on Firms if Faced with an Energy Price Increase, as a Proportion of a Sector's Responses

	Impacts on firms by sector as a proportion of number of firms							
Sector	Increase profits (%)	Pass on costs (%)	No effect (%)	Some reaction required (%)	Fall in profits (%)	Would be difficult to compete (%)	Large negative impact (%)	Close or relocate (%)
Energy-intensive: resource-based	3	4	11	11	40	4	5	21
Energy-intensive: manufacturing	4	8	17	8	38	8	4	16
Energy-intensive: transportation services	3	4	11	6	41	4	6	18
Capital-intensive: oil and gas extraction	27	0	21	3	27	0	0	9
Capital-intensive: mining	3	0	12	3	42	2	3	18
Capital-intensive: electric	21	5	30	7	23	2	7	5
Capital-intensive: other	4	3	15	5	28	2	10	10
Transportation equipment manufacturing	1	8	16	13	42	6	3	13
Other manufacturing	2	8	24	6	36	4	8	10
Other services	–	9	25	7	41	2	2	8
All sectors	**4**	**6**	**18**	**7**	**37**	**4**	**5**	**13**

Source: Panel survey data (Q35)

Respondents were allowed to respond in any fashion, and those responses were then classified into groups of responses. Most of the responses were clear in that they related specifically to financial variables such as the impacts on costs or profits.

been in demand in rapidly growing developing economies. However, because of the greater adverse impact of the recession on mineral prices compared with oil and gas prices, this sector may now be feeling relatively more exposed to higher energy prices.

Table 6.4 shows the possible impact of energy price declines. The patterns of impacts of lower energy price on firms are roughly symmetrical with those of higher prices in Table 6.3. In both cases, around 18% of firms said that there would be no impact (although they were not necessarily the same firms), with 10% saying price increases would have a positive impact, and 3% saying price declines would have a negative impact. However, anticipated reactions to the impact of a price fall in general were moderate with significant concern limited to the oil and gas sector.

Table 6.4

Impacts on Firms if Faced with an Energy Price Decline, as a Proportion of a Sector's Responses

	Share responding					
Sector	Large positive impact (%)	Reduce price to consumers (%)	Reduction in costs – general positive impact (%)	No impact (%)	Profits decline – reduction in employment (%)	Closure (%)
Energy-intensive: resource-based	11	11	69	11	1	0
Energy-intensive: manufacturing	17	17	61	13	2	0
Energy-intensive: transportation services	14	14	58	14	3	1
Capital-intensive: oil and gas extraction	3	3	36	18	21	9
Capital-intensive: mining	18	18	68	15	0	0
Capital-intensive: electric	9	9	30	37	12	2
Capital-intensive: other	12	12	60	18	3	0
Transportation equipment manufacturing	15	15	62	18	0	0
Other manufacturing	8	8	64	19	2	0
Other services	11	11	56	25	2	0
All sectors	**13**	**13**	**59**	**18**	**3**	**0**

Source: Panel survey data (Q36)

6.2 VULNERABILITIES AND OPPORTUNITIES CREATED BY ENERGY PRICE CHANGES

6.2.1 Vulnerabilities

According to the evidence in the literature outlined in Chapter 3, the types of firms exposed to energy prices are likely to be in sectors that use capital or energy intensively or produce goods and services that are complements to energy. Although these results were largely confirmed by the survey, there is a broad concern about energy prices, particularly in firms that tend to use energy derived from oil-based products. Survey respondents were asked to state how important energy prices were to their competitiveness (see Table 6.5). This degree of concern was higher in the sectors that the Panel identified as exposed to changing energy prices. The transportation services sector expressed the greatest concern, with nearly two-thirds of respondents saying that it was "extremely important." However, the degree of concern was high even among those sectors not as exposed to energy costs. One-third of respondents in the other manufacturing and services sectors said that energy costs were extremely important to them. The most diverse response was from sectors linked to energy production — oil and gas and electric power — where higher prices for their outputs will offset the impact of higher prices on their cost structures.

Table 6.5

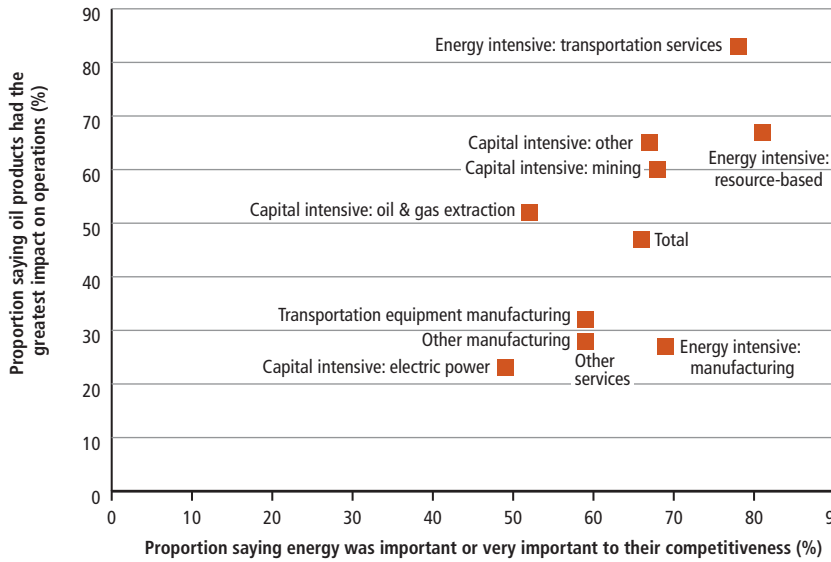
Importance of Controlling Energy Costs to Maintaining Competitiveness, by Sector

	Share responding				
Sector	1 Not at all important (%)	2 (%)	3 (%)	4 (%)	5 Extremely important (%)
Energy-intensive: resource-based	5	4	9	27	53
Energy-intensive: manufacturing	9	9	11	22	47
Energy-intensive: transportation services	4	5	13	16	62
Capital-intensive: oil and gas extraction	21	12	15	9	42
Capital-intensive: mining	5	8	18	18	50
Capital-intensive: electric	26	5	19	14	35
Capital-intensive: other	10	7	15	23	44
Transportation equipment manufacturing	11	7	23	23	35
Other manufacturing	7	19	15	27	32
Other services	16	11	14	23	36
All sectors	**10**	**9**	**15**	**22**	**44**

Source: Panel survey data (Q7)

Concern about the competitiveness impacts of energy prices was higher among firms that said that oil prices had the biggest impact on their business. Of these firms, 50% said energy was extremely important to their competitiveness compared with 38% of those using natural gas and 39% of those using electricity. To determine whether the overall concern in firms using oil products might reflect oversampling of transportation services firms (relative to their contribution to national GDP) in the survey, the Panel examined the correlation between the proportion of firms in a sector that indicated that energy was important or extremely important to their competitiveness, and the proportion of firms in that sector using a particular fuel. The proportion concerned about competitiveness was positively correlated with the proportion that said oil was the main fuel used, and negatively correlated with the proportion that said gas or electricity was the main fuel used.

Figure 6.1 plots the proportion of a sector that stated that oil products had the greatest impact on their operations against the proportion that said that energy costs were either important or very important to their competitiveness. The sample correlation between these proportions (0.69) may arise because volatility and upward price momentum have been concentrated recently in the oil markets.



Source: Panel survey data (Q7 and Q10)

Figure 6.1

Competitiveness Concerns and Use of Oil-Based Products, by Sector

The figure shows that the concern about energy for a firm's competitivenss was correlated with the proportion that said oil products had the greatest impact on operations. This association suggested that vulnerability was associated with making intensive use of oil products. In the figure, other services and other manufacturing sectors share the same data point.

Detailed examination of the data in the survey yielded additional characteristics of firms that would be most concerned about competitiveness impacts. Larger firms tended to be more concerned than smaller firms: 82% of large firms said that energy costs were important or extremely important to their competitiveness compared with 58% of micro-sized firms (fewer than five employees). Concern generally increased with energy intensity, but was fairly constant after reaching a threshold of firms saying that energy costs were 15% or more of their costs.[33]

6.2.2 Opportunities

Analysis of survey results suggests that the most likely firm strategy would be to invest in new equipment, creating opportunities for producers of such equipment. However, it also appears that some would consider switching fuels, probably to natural gas.

When asked whether they were likely to switch fuels, invest more in energy-efficient equipment, or relocate operations over the coming decade (without being prompted by a specific energy price scenario),[34] by far the most likely action anticipated by firms was to invest more in energy-efficient equipment (see Table 6.6). The likelihood of further investment was up to one-third higher in some of the energy-intensive sectors than in the other services sector. The 55% of firms that said they would invest in new equipment in the future was similar to the share (59%) of firms in Table 6.1 that had reacted to past price increases by investing in new equipment. Firms therefore consistently look to invest in energy-efficient equipment in response to higher energy prices.

The proportion of firms reporting that they would switch fuels averages 21%, higher than the 15% that had made this change in the previous five years. The highest likelihood of fuel switching, at 29%, was in transportation services, much higher than the 20% reporting having pursued this option previously. This finding suggests that transportation firms are considering switching to natural gas or electricity, options that are becoming more feasible technically (see Chapter 2). There were also increases in the likelihood of changing fuels in the electric power and other manufacturing sectors. The lower likelihood of switching fuels in other sectors may reflect that they are already using natural gas or electricity.

33 The impact of energy prices on firm behaviour was not strongly related to exporting in the survey. There was no strong link between concern about the impact of energy prices on competitiveness and export intensity.

34 Respondents were also able to list other options, but those answers were not easily classified, although they indicated that detailed solutions are being considered.

Table 6.6

Anticipated Actions Over the Next 10 Years, by Sector

	Reaction as a share of sector total		
Sector	Switch fuels (%)	Greater investment in energy-efficient equipment (%)	Relocate operations (%)
Energy-intensive: resource-based	23	56	7
Energy-intensive: manufacturing	16	54	5
Energy-intensive: transportation services	29	60	7
Capital-intensive: oil and gas extraction	18	55	15
Capital-intensive: mining	22	55	5
Capital-intensive: electric	23	58	9
Capital-intensive: other	25	56	10
Transportation equipment manufacturing	17	47	9
Other manufacturing	21	60	12
Other services	16	46	10
All sectors	**21**	**55**	**8**

Source: Panel survey data (Q26)

Survey respondents were asked: "Do you anticipate making any of the following changes related to energy use in the next 10 years?" The table shows the proportion of firms in a sector that chose one of the specific options given to them. Firms may choose to react in multiple ways, and were not given a particular energy price scenario.

Table 6.7 explores which energy sources are likely to experience changes. The first data column gives the share of those using a particular fuel that would switch fuel (as in the first data column of Table 6.6). Hence, of all firms that would switch fuels, 68% currently use oil-based products. The second column shows the share of total firms using a fuel in the survey: 92% of respondents currently use either oil-based products or electricity as their major source of energy. The last column gives the share of those currently using a particular fuel that would change their fuel source. Of those using oil, 31% would change fuel compared with 12% of those using electricity. Table 6.7 is a snapshot of the turbulence caused by the emergence of cheap natural gas since 2010 with those currently using oil-based products thinking of switching. Even those currently using electricity may be considering moving to natural gas.

Table 6.7
Likelihood of Changing Fuel Source

Fuel Source	Share of: All firms that would switch fuels (%)	All firms using fuel (%)	Anticipating changing fuel, by current fuel used (%)
Oil products	68	47	31
Natural gas	7	9	17
Electricity	25	45	12

Source: Panel survey data (Q10 and Q26)

The first data column gives the share of those using a particular fuel that would switch fuels. The second column shows the share of all firms using a particular fuel in the survey. The last column gives the share of those currently using a particular fuel that would change their fuel source.

The Panel also tried to explore the potential opportunities for firms in periods of changing energy prices, based on questions in its survey. First, which sectors would face increased demand for their products? Second, more generally, would higher prices create opportunities, and if so, what would they be? However, the survey did not provide much in the way of useful responses. In response to an open-ended question as to whether higher or more volatile energy prices would create opportunities, 21% of firms said that such conditions would provide opportunities. However, the sample size was too small to yield insights on what those opportunities might be. The proportion of firms that would see increased demand for their products was very small (at around 3% of the sample). This survey outcome highlighted to the Panel that opportunities from higher energy prices could arise increasingly for a group of industries other than those directly exposed to energy prices: those producing equipment, designing software, manufacturing electronics, or providing consulting services that could aid firms in lowering their exposure to energy prices are not themselves energy intensive.

6.3 PREPAREDNESS OF SECTORS FOR CHANGING ENERGY PRICES

In this section, the Panel addresses the preparedness of Canadian sectors to capitalize on opportunities or mitigate risks that result from changing energy prices. Although a high proportion of firms in all sectors feel exposed to energy prices, a smaller proportion is taking action to be prepared. To assess the degree of preparedness, the Panel developed three indicators based on answers to questions asked in its survey (see Section 5.4).

The first indicator — access to timely, accurate, and relevant information about the evolution of energy markets — captures those who make use of more detailed news sources whether from internal sources, government agencies, professional sources such as banks, industry associations, or suppliers and customers. The second indicator is whether a firm has access to benchmarking information. The third indicator is whether a firm has access to specialized personnel who understand the implications of energy price movements for the business. These could be financial and/or technical analysts.

Firms that meet the criterion of one of the indicators tend to meet the criteria of the others. This section correlates these indicators with propensities of sectors to change. Although causality cannot be established, the results suggest that those that change strategies in the face of energy price changes score better on these indicators. These firms, according to the Panel's hypothesis, are more likely to be resilient to changing energy prices.

6.3.1 Sources of Information

Concerns have been raised in other studies about the energy literacy of Canadian business leaders (Moore *et al.*, 2013) (Section 3.2.3). The Panel investigated this issue in its survey, and found that a large number of firms surveyed also appear to be relying mainly on news reports to stay informed about the future of energy prices. The Panel also explored the association between possessing more and better information and the likelihood of taking action in response to changing energy prices. Sectors exposed to energy price changes are also more likely to have relevant information.

Table 5.12 reported the sources of information on energy prices used by firms surveyed by share of total respondents. For example, half of firms obtained information from the news or the internet as well as other sources, while 8% of firms did not rely on price forecasts at all. To examine this issue further, the Panel focused on those firms that rely exclusively on the news or internet to obtain information, which represented 29% of the survey sample (see Table 6.8). These firms were more likely to be smaller firms. About one-third of firms with fewer than 100 employees obtained information only from the news or internet, compared with one-fifth of firms with 100 or more employees. However, firms getting their information in only this way were marginally less concerned about the importance of energy costs to their competitiveness: for the full sample, 66% said energy was important or very important to their competitiveness

(Table 6.5), compared with 60% of those that obtained their information only from the news or internet.[35] This small difference could signal that demand for information exists, but there are barriers to accessing relevant information.

There were differences across sectors in how firms obtain information, as shown in Table 6.8. Mining, oil and gas, and energy-intensive manufacturing are less likely to get their information only from the news or internet. The highest proportion of firms that get their information only from the news or internet is in other manufacturing and other services, which is to be expected given that these are not exposed sectors.

Table 6.8

Obtaining Information Only from News or Internet, by Sector

Sector	Share of sector that only gets information from news or internet (%)
Energy-intensive: resource-based	31
Energy-intensive: manufacturing	19
Energy-intensive: transportation services	28
Capital-intensive: oil and gas extraction	21
Capital-intensive: mining	23
Capital-intensive: electric	28
Capital-intensive: other	24
Transportation equipment manufacturing	34
Other manufacturing	36
Other services	38
All sectors	29

Source: Panel survey data (Q15)

6.3.2 Benchmarking Information

This section reviews the survey results on the availability of benchmarking data, and correlates them with other responses on the types of information available to firms and their exposure to energy prices. Firms appear to gain from access

35 Those acquiring information only from the news or internet were slightly more likely to use oil, but the proportion was unrelated to exports or the share of energy costs. There was a degree of variability across regions, but it was not large. Further analysis was not undertaken because of small sample sizes.

to benchmarking data. However, gathering these data can be difficult because of firms' confidentiality concerns. Consequently, despite the potential demand by firms for benchmarking data to improve their preparedness, it may not be feasible for many sectors to develop them.

Eighteen per cent of survey respondents have benchmarking information (see Table 6.9). Some firms among the sectors identified as exposed to energy prices were more than twice as likely as firms in the other manufacturing and service sectors to have benchmarking information.

Table 6.9
Access to Benchmarking Data, by Sector

Sector	Share of sector that has benchmarking data (%)
Energy-intensive: resource-based	24
Energy-intensive: manufacturing	17
Energy-intensive: transportation services	24
Capital-intensive: oil and gas extraction	24
Capital-intensive: mining	28
Capital-intensive: electric	30
Capital-intensive: other	16
Transportation equipment manufacturing	13
Other manufacturing	9
Other services	13
All sectors	18

Source: Panel survey data (Q17)

A higher proportion of firms that are concerned about energy costs for their competitiveness have access to benchmarking data (Table 6.10). Whereas 8% of firms that said energy costs were not important to their competitiveness had such data, 25% of those that said they were extremely important had them. The incentive to seek relevant information is related to the degree of concern about competitiveness.

Table 6.10

Access to Benchmarking Data by Concern about Competitiveness

How important is controlling energy costs as part of maintaining the competitiveness of your firm?	Proportion of firms that had benchmarking data (%)
1 Not at all important	8
2	6
3	11
4	19
5 Extremely important	25
All firms	18

Source: Panel survey data (Q7 and Q17)

More detailed examination suggests that firms with benchmarking information (i) stated disproportionately that energy costs were extremely important to their competitiveness, and (ii) were in sectors exposed to energy prices (i.e., not in the other manufacturing and service sectors) (data not shown). Further, although sample counts are small, only one-fifth of small firms in the survey for whom energy costs were extremely important had benchmarking information. There was no clear link between having benchmarking data and whether energy costs had gone up, down, or stayed the same. As energy costs increase as a proportion of operating costs, a higher proportion of firms have benchmarking data (Table 6.11).

Table 6.11

Benchmarking and the Importance of Energy Costs

Approximately what proportion of your operating costs are energy costs?	Do you have information that allows you to benchmark your energy efficiency against your competitors?	
	Yes (%)	No (%)
0% to 15%	11	86
15% to 30%	24	73
30% to 50%	26	72
50% and over	32	65

Source: Panel survey data (Q8 and Q17)

Respondents were asked about the time spent by senior management discussing energy prices at meetings (Section 5.4.1). For 64% of firms with access to benchmarking, energy prices were discussed often or always at meetings (see Table 6.12). On the other hand, energy prices were only discussed 32% of the time in meetings for firms without access to benchmarking.

Table 6.12

Benchmarking and the Time Management Spends on Energy

How often is energy prices discussed at meetings of senior management?	Do you have information that allows you to benchmark your energy efficiency against your competitors?	
	Yes (%)	No (%)
Always	30	11
Often	34	21
Sometimes	21	22
Rarely	9	23
Never	2	21
Don't know/No response	4	3

Source: Panel survey data (Q14 and Q17)

Firms were asked how they compared with competitors in terms of energy efficiency (Table 6.13). This question was asked independently of whether firms had benchmarking information. For those without benchmarking information, the response "don't know" was high at 38%. Of firms with access to benchmarking information, 31% said that they were either more or much more efficient than their competitors compared with 15% of firms without benchmarking information. Those with benchmarking information could be working harder at reducing energy costs, and they may have some evidence to back their claims within the organization that reducing energy costs should be a management priority.

Table 6.13

Benchmarking and Information About Competitors

How does your firm compare in energy efficiency with your competitors?	Do you have information that allows you to benchmark your energy efficiency against your competitors?	
	Yes (%)	No (%)
Much less	3	4
Less	7	5
Same	52	39
More	17	10
Much more	14	5
Don't know/No response	8	38

Source: Panel survey data (Q19 and Q17)

When asked whether they were aware of energy efficiency measures taken by their competitors, 60% of firms with benchmarking information were aware, compared with 16% without the information (see Table 6.14).

Table 6.14

Benchmarking and Awareness of Competitors' Actions

Are you aware of energy efficiency measures taken by your main competitors?	Do you have information that allows you to benchmark your energy efficiency against your competitors?	
	Yes (%)	No (%)
Yes	60	16
No	37	76
Don't know/No response	3	8

Source: Panel survey data (Q20 and Q17)

The Panel also looked at a smaller group of firms that appeared to be particularly concerned about energy and were also well informed. The group, representing 15% of the surveyed firms, stated that energy was important to their competitiveness and had access to benchmarking data. This group was more likely to use oil than the full sample (58% versus 47%) and more likely to be more energy intensive. Interestingly, this group was again more likely to have changed strategy or operations in 2008 in response to price volatility, mirroring the previous finding that firms that changed strategy were less likely to get their information from the news or internet. In 2008, 60% of this group

changed strategy or operations compared with 42% of the full sample and 49% of those that only said energy was important to their competitiveness (i.e., with or without benchmarking information).

On balance, it seems that firms that changed strategy or operations in 2008 in response to higher and more volatile oil prices were better informed in terms of their information sources and their access to benchmarking data. They were also more likely to be more energy intensive.

6.3.3 Availability of Appropriate Personnel

Better decision-making relies on having access to the latest information, technologies, and data. Employing people focused on these issues enables senior managers to be aware of ongoing trends in energy markets, and facilitates effective and timely decision-making. Table 6.15 shows that the oil and gas, electric power, and transportation sectors are most likely to employ dedicated personnel knowledgeable about energy issues.

Table 6.15

Employment of Staff Analyzing Energy Impacts, by Sector

	Share of sector that has:		
Sector	A person doing financial analysis on impact of energy prices (%)	A person doing technical analysis related to energy (%)	Both (%)
Energy-intensive: resource-based	19	12	10
Energy-intensive: manufacturing	22	19	9
Energy-intensive: transportation services	27	21	17
Capital-intensive: oil and gas extraction	33	24	15
Capital-intensive: mining	25	15	12
Capital-intensive: electric	28	28	19
Capital-intensive: other	20	15	9
Transportation equipment manufacturing	15	13	7
Other manufacturing	18	13	5
Other services	21	14	10
All sectors	22	16	10

Source: Panel survey data (Q13 and Q21)

6.3.4 Interactions of Indicators of Preparedness and Business Change

The three indicators of preparedness developed by the Panel are related to each other in that firms that meet the criterion of one indicator often meet the criteria of the others. Furthermore, the indicators are associated with changing strategies when affected by changes in energy prices (see Table 6.16). For example:

- For firms that get information from professional sources, 30% also have access to benchmarking data versus 18% in the overall sample.
- Of firms with access to benchmarking information, 39% employ a person who looks at the financial impact of energy costs compared with 18% of those without benchmarking information.
- Of firms with access to benchmarking information, 33% employ a person who undertakes technical analysis on energy issues compared with 12% of those without benchmarking information.

Table 6.16

Benchmarking and Employment of Dedicated Personnel

Do you have information that allows you to benchmark your energy efficiency against your competitors?	Proportion employing a person to undertake:	
	Financial or economic analysis of energy costs (%)	Technical analysis on matters related to energy (%)
Yes	39	33
No	18	12

Source: Panel survey data (Q13, Q17, and Q21)

The survey asked about how firms responded to the price volatility in 2008.[36] Although 43% of respondents in the sample changed strategy in response to energy price changes, only 33% of those firms that get their information only from the news or internet also acted in response to higher and more volatile prices. Of those that get information from internal sources, government agencies, professional sources such as banks, industry associations, and suppliers and customers, this proportion increased to 60%.

Table 6.17 cross-tabulates access to benchmarking data with whether firms had changed strategy in 2008 in response to increased price volatility. One in four firms that had changed strategy had benchmarking information (10% versus 43%). Of those firms that did not change strategy, one in eight had data (7% versus 54%). Of those with benchmarking information, three of five firms changed strategy (10% versus 17%), whereas two of five firms without benchmarking information changed strategy (31% versus 77%).

36 Analysis of this question was restricted to those who said that their firm had been in operation for more than four years in 2013.

Table 6.17

Benchmarking and Changing Strategy in 2008

Do you have information that allows you to benchmark your energy efficiency against your competitors?	Around 2008 we saw a market increase in volatility in the price of oil and gas. Did your firm make any changes in strategy or operations to cope with increased volatility?		
	Share of total sample		
	Yes (%)	No (%)	Total (%)
Yes (%)	10	7	17
No (%)	31	46	77
Total (%)	43	54	

Source: Panel survey data (Q17 and Q12)

The sample for this question was restricted to firms in operation for more than four years. The total number of "don't knows" was 30 (3.2% of sample).

Of firms that had changed strategy in 2008, 47% had an employee looking at energy prices from the financial perspective compared with 33% of those that had not changed strategy, and 40% had a person responsible for technical aspects compared with 24% for the rest. These firms that changed strategy were more likely to discuss energy matters in management meetings (67% to 57%), and more likely to get information from industry associations and internal reports (64% to 50%). They were also very likely to know about the efficiency measures taken by competitors (66% to 52%). This proportion is greater than the 60% of all firms with benchmarking information, and greater than the 16% without benchmarking information.

The evidence presented here — consistent with the broader empirical literature reviewed in Chapter 3 — suggests that benchmarking is valued by firms. It is less clear whether firms with access to such data are encouraged to change, or whether firms that have determined to change seek out such data. However, this correlation suggests that access to benchmarking data facilitates the process of adapting to energy prices, and hence is a valid indicator of preparedness.

Box 6.1 highlights the benchmarking exercise of the Forest Products Association of Canada, which has now been expanded internationally. A question asked in the survey on whether firms had information that allowed them to benchmark their energy efficiency against their competitors sheds some light on the wider availability of such data. Overall, only 18% of survey respondents had access to such information. An interesting observation is that while 5% of all firms in the survey were foreign controlled, 10% of firms with benchmarking information were foreign controlled.

Box 6.1
Benchmarking in the Canadian Forest Products Industry

Every second year, the Forest Products Association of Canada surveys the entire industry (wood products and pulp and paper facilities) on energy use. Detailed data are gathered on all mills in Canada by type of production (78 pulp and paper and 107 wood products facilities). The response rate to the survey averages around 85%. The survey results are then returned to the respondents and their parent company when appropriate. Each respondent/parent company sees the performance of their own mill(s) and where it ranks in comparison with all other mills. Such information allows managers to benchmark their performance, and realize what operational improvements are possible. In 2012, a similar international exercise was carried out covering 10 countries based on data for 2011, and is planned to be repeated every five years.

6.3.5 Preparedness of Sectors

As noted at the beginning of the section, the indicators available to the Panel to capture preparedness relate to accessing relevant information about energy prices, employment of relevant personnel, and benchmarking. Table 6.18 examines the preponderance of these metrics across sectors.

Among the surveyed firms, 63% met the criterion of one of the three indicators with a higher proportion among those sectors exposed to energy prices. While just under 25% of all firms surveyed met two of the three criteria, only 5% met all three. The oil and gas, electric power, and transportation sectors rank the highest by these indicators of preparedness. There are no major differences between the remaining five exposed sectors, though all have higher response rates than the two sectors that are not exposed to higher energy prices: other services and other manufacturing.

It is also notable that the patterns of preparedness are roughly consistent across sectors. This result suggests that the major difference in preparedness is not at the sectoral level, but across firms within sectors. This finding is in keeping with other economic analyses that show significant differences in firm performances within any given sector, as surveyed by Syverson (2011).

The survey results reveal that a sizeable proportion of firms in all sectors are taking actions to be prepared for higher energy prices. However, it is not possible for the Panel to determine whether this proportion is sufficient. The Panel suspects that more firms would like to have access to resources that would enable them to be better prepared, but face barriers in doing so.

Table 6.18

Determining the Degree of Sectors' Preparedness

	Share of firms with access to:					
Sector	Access to detailed information (%)	Bench-marking (%)	Specialized personnel (%)	Any of the three indicators (%)	Any two of the three indicators (%)	All three indicators (%)
Energy-intensive: resource-based	55	24	19	66	28	4
Energy-intensive: manufacturing	60	17	22	69	27	4
Energy-intensive: transportation services	58	24	27	67	32	10
Capital-intensive: oil and gas extraction	67	24	33	76	36	12
Capital-intensive: mining	47	28	25	65	30	5
Capital-intensive: electric	65	30	28	72	37	14
Capital-intensive: other	51	16	20	64	21	3
Transportation equipment manufacturing	50	13	15	58	15	5
Other manufacturing*	49	9	18	60	13	2
Other services*	38	13	21	52	18	2
All sectors	**52**	**18**	**22**	**63**	**24**	**5**

Source: Panel survey data

* Sectors that are not exposed to energy prices.

6.4 CONCLUSION

Sectors that are exposed to energy prices include those firms that are capital and energy intensive, and firms that produce goods and services that are complements of energy. The Panel's survey suggests that the mining, transportation services, and energy-intensive resource-based sectors are the most vulnerable to higher energy prices. Vulnerability appears to be heightened in firms that use oil-based products.

Opportunities are created in times of higher prices for energy-producing sectors (the capital-intensive oil and gas and electric power sectors) and for firms producing energy-efficient equipment. Furthermore, lower natural gas prices in North America suggest that there are opportunities to switch the type of fuel used. The Panel was not able to identify industries that would see increased demand for their products if energy prices were to rise, but speculates that these are in sectors that have not been directly affected by energy prices in the past, such as software design and electronic manufacturing firms.

The resilience of firms can be improved by the types of strategies and management practices they put in place. In this respect, the indicators that the Panel developed give some sign of how prepared firms are for future changes in energy prices. Responsiveness and adaptability tend to be greater with access to specialized skills and information related to energy markets. That firms more exposed to energy prices adopt these practices suggests that it makes business sense to demand these resources. Firms without access to these resources may want to be better prepared but may be challenged in obtaining data because of the high degree of commercial sensitivity.

Overall, the survey data suggest that an opportunity exists for many Canadian firms to become better prepared for a future of high and volatile energy prices by accessing better and timelier information and employing specialized personnel. To aid business decision-making, the information sources that would be particularly valuable for firms are benchmarking data on energy efficiency and access to price projections for sources of energy in the Canadian context.

7

Conclusions

- Responding to the Charge
- Responding to the Sub-Questions
- Final Reflections

7 Conclusions

This chapter synthesizes the evidence and findings that have emerged from previous chapters to provide answers to the main question and sub-questions that comprise the charge, and offers some final reflections. In addressing the charge, the Panel has based its conclusions on its review, interpretation, and analysis of the evidence, assisted by its expertise and deliberations on the issues.

Consistent with the interpretation of the charge agreed with the Sponsor, the Panel concentrated on the direct impact of energy prices on Canadian business decision-making. The Panel drew on the theoretical and empirical economics literature to determine what types of firms are relatively the most exposed to energy prices. Heightened exposure to energy prices is more likely in sectors that are capital or energy intensive, or that produce goods and services complementary to energy. The Panel identified eight sectors that were exposed.

An important aspect of business management is resilience: the capacity to bounce back from adverse events. The Panel first examined the resilience of Canadian firms to previous changes in energy prices by looking at the performance of selected sectors since 2000. According to the data, these sectors made significant adjustments to their business operations to reduce energy intensity. Since the experience of firms within a sector may be quite different, it is not possible to draw conclusions about the resilience of firms. However, there is clear evidence of sectoral resilience in the face of the types of changes to energy prices experienced in the past, as energy intensities have declined steadily. Data limitations, however, made it impossible to compare this resilience with adjustments made in other countries.

Being prepared for change is an important factor in firms' resilience. Little direct evidence, however, was available to the Panel on the extent to which firms were prepared for such change in future years. To explore the concept of preparedness, the Panel drew on ideas from the management literature, and also commissioned a survey to assess the extent to which firms in exposed sectors meet certain indicators of preparedness. These indicators, developed by the Panel, included whether firms employ dedicated staff, have access to informed sources of information about energy futures, and use benchmarking data on the energy efficiency of competitors. The survey results suggested that these indicators of preparedness are associated with taking action in response to changes in energy prices, and yield insights into the preparedness of firms and sectors.

Survey results also showed that, on the basis of these indicators, many firms in Canada are prepared for price changes. Just over one-half of firms have access to timely, accurate, and relevant information about the evolution of energy markets. Around one-fifth of firms have access to benchmarking data on plant performance or employ specialized personnel. For those firms apparently less well prepared, it was not possible to establish from the survey whether there were structural barriers to obtaining some types of resources that support preparedness. Business demand for those elements captured by the Panel's indicators increased with the degree of exposure of energy prices, but only one-quarter of surveyed firms met the criteria of two of the three indicators.

The resilience of firms to changes in energy prices will be tested as energy markets become more complex, creating additional risks that will complicate business decision-making. There are a number of features of this complexity. New reserves of natural gas are now being exploited, lowering its price in North America. New infrastructure will link energy markets both within the continent and overseas. A myriad of environmental and safety issues are associated with different types of energy. Moreover, technological change is faster and coming from industries not linked traditionally with energy markets, such as from software and electronic manufacturing firms. Based on its experience and what it has learned, the Panel identifies some issues that may benefit from further research in Section 7.3.

7.1 RESPONDING TO THE CHARGE

Main Question

What are the opportunities and risks to Canada related to the potential for sustained higher energy prices?

This question is not as straightforward as it perhaps once was. In some respects, the future global context for energy prices will be a repetition of the past. Global economic growth will stimulate demand for all types of energy. In particular, growth in Asia will increase demand for oil-based products for transportation. In other respects, however, the North American energy context is being transformed by the availability of natural gas resources that, until recently, were thought to be uneconomic. Technological advances are also driving increased production of tight oil. Decisions pending on the construction of pipelines at the time of writing this report will have important ramifications for Canadian business going forward.

In broad terms, opportunities will stem from Canada's relative abundance of energy resources and apparent past ability of users to adapt to rising prices by reducing energy intensity. The Panel found that expected trends in energy prices will provide opportunities for some sectors. Continued lower natural gas prices relative to oil will enhance the competitiveness of the Canadian chemical manufacturing industry. Higher energy prices will provide opportunities for firms that produce and transport energy, as well as those that provide energy-efficient manufacturing equipment or facilitate the transition to the use of natural gas.

Nevertheless, the increasing complexity of energy markets will generate risks that extend beyond changes in price. The increased availability of natural gas, the potential for new technologies, and enhanced concern about environmental and safety implications of developing, transporting, and using fossil fuels will complicate decision-making. Obtaining approvals for infrastructure associated with energy development is taking longer than ever before, and this creates an additional level of uncertainty in business decisions about capital investment for future energy use. To cope with this increased complexity, new management skills and capabilities — such as increased and improved information — will be required to strengthen the resilience of Canadian firms.

The availability of increased energy supplies in the United States may also affect Canadian firms in several respects. First, most of Canada's energy exports have traditionally headed south of the border, but the demand for these exports will decline. Second, Canadian firms have been partly sheltered from changes in global energy markets because the abundance of domestic energy sources and government policies have kept prices relatively low. Firms in other countries have had a head start in developing energy-efficient equipment given Canada's relatively low prices, but Canadian firms may be able to benefit from adopting this equipment as prices rise. Although adjusting to shocks in global energy markets has been challenging for many Canadian firms, Canadian business has generally adapted well and overcome risks in the past.

7.2 RESPONDING TO THE SUB-QUESTIONS

1. *Looking forward, what are the expected impacts of higher energy prices on Canadian businesses?*

The impacts of energy prices on Canadian business are best examined at the sectoral level. There are important differences across sectors in their relationship to energy prices, the strategies they employ, and the opportunities and risks they face in periods of changing prices.

The decoupling of prices for different sources of energy means that there is no single energy price. Whether for use as a source of energy or as a feedstock, the price of natural gas is now significantly lower than the (energy-equivalent) price of oil, and is expected to remain so for some time. In addition, electricity prices are generally influenced by government policy in most provinces, and therefore may not closely track prices in traded energy sources. In considering how energy prices may evolve in the future, increasing concerns about the environment and safety, as reflected in enhanced regulations, will put upward pressure on the prices of fossil fuels, as well as complicate decision-making on energy-associated infrastructure investments.

On the basis of the theoretical analysis and literature review in Chapter 3, the Panel identified eight sectors that, in its judgment, are exposed to higher energy prices: the energy-intensive resource-based, manufacturing, and transportation sectors; the capital-intensive oil and gas, mining, electric power, and other sectors; and the transport equipment sector. These sectors, along with two additional sectors that are not particularly energy intensive, were then analyzed in Chapter 4 to assess the impacts of past increases in energy prices. A sample of firms in these sectors was also surveyed to get a better understanding of the importance of energy prices to their operations, how they had adjusted in the past, and how prepared they were to adjust to future energy price shocks. There are likely to be significant direct impacts of energy prices on firms in these sectors, but fostering their resilience to energy prices can mitigate economic harm.

Firms typically respond to higher or more volatile energy prices by investing in energy-efficient capital, introducing more energy-efficient processes, switching fuel sources, and hedging energy prices with financial instruments. Where higher costs are passed through to product prices, customers may purchase less energy-intensive goods over time. Where costs cannot be passed through, the return on investment would be lowered, leading investors to reallocate their investments to other sectors. Firms that produce energy-intensive products (e.g., automobiles, aircraft, and appliances) also have an incentive to make them more energy efficient when energy prices increase.

The empirical sectoral evidence reviewed in Chapter 4 shows that exposed sectors in Canada have coped with higher energy prices in the past by substantially lowering their energy intensity. Between 2000 and 2008, the truck transportation industry, for example, lowered its energy intensity by an annual average of 4% while the non-metallic mineral product manufacturing industry (which includes production of materials such as glass and cement) lowered its energy intensity by an average of 2%. In the face of similar price changes in the future,

exposed firms will be adversely affected, but will adjust over time. To the extent that firms are resilient, including being prepared for higher and more volatile energy prices, the adjustments can be more rapid and less painful.

In considering the survey results, 74% of firms indicated that they had changed strategy in response to high and volatile oil prices in 2008. Of those that had changed strategy, most did so by undertaking investment in more energy-efficient equipment (59%) and/or switching fuels (15%). The decision to change strategy was relatively uniform across sectors, except for oil and gas. Of the firms surveyed, 61% expected to make changes in their operations related to energy use over the next 10 years. The major changes identified included greater investment in energy-efficient equipment (55%) and switching fuels (21%), a higher rate for the latter than in the past. The Panel concluded that the direct impact on firms exposed to energy prices will be to encourage them to invest in energy-efficient equipment and, increasingly, to consider switching to natural gas as a source of energy, including in the production of electricity.

2. *How do Canadian businesses compare to foreign competitors in terms of their ability to adapt to a) sustained higher energy prices? b) energy price volatility episodes?*

There are few available data and little research that allow a comparison of the ability of Canadian and international firms to adapt to energy prices and volatility. In general terms, industry-by-industry comparisons demonstrate similar energy intensities in the United States and Canada for those sectors for which comparable data are available. This suggests that Canadian firms would be unlikely to face major competitiveness challenges — in terms of lost market share — if global energy prices and volatility were to increase, and if they were able to adjust as effectively as their counterparts in the United States. There are no readily available data that allow sectoral comparisons of the energy intensity of Canadian firms with that of firms in countries other than the United States.

The Panel noted that access to information on competitors would be a possible signal that Canadian firms are concerned about how they compare with foreign firms. However, even for those firms in the Panel's survey that judged energy prices as extremely important to their competitiveness, less than one-third had information on benchmarking or knowledge of their competitors' energy efficiency measures.

The Panel found no evidence to suggest that increases in energy prices or price volatility, on a global basis, would have an adverse impact on the competitiveness of Canadian firms relative to foreign competitors. Indeed, the lower level of energy prices in Canada, compared with industrial economies outside of North America, suggests that there may be scope to increase energy efficiency in Canadian firms at a lower cost than may exist elsewhere should energy prices increase.

3. *Which industry sectors and communities are inherently a) most vulnerable to higher energy prices? b) best equipped to leverage higher energy prices as a competitive advantage?*

As detailed in the report, higher energy prices pose challenges for all sectors. Two-thirds of the firms surveyed reported that energy costs were very important or extremely important to their competitiveness. Firms that use energy intensively in their production processes (e.g., pulp and paper manufacturing) or use large amounts of capital (e.g., mining) are particularly exposed to higher energy prices as their costs of energy or new equipment may increase.

The Panel found that most of the exposed sectors had adjusted successfully to past episodes of higher and more volatile oil prices. Some sectors, however, have struggled. Chemical manufacturing had been challenged since 2000, but this picture is now reversing as the relative price of natural gas declines in North America. Parts of the motor vehicle manufacturing industry — a constituent of the transport equipment sector — also struggled as gasoline prices rose. In many other cases, however, energy-intensive industries were facing more fundamental technological challenges, such as the effect of the digitization of media on the paper manufacturing industry. Identifying their main challenge as exposure to energy prices would not have been appropriate.

The concern about energy prices for competitiveness was greater among those firms using oil-based products. The Panel expects oil prices to continue to increase in real terms, and the recent decoupling of natural gas and oil prices to persist. The implications are that those firms using primarily oil-based products will be potentially vulnerable, but many of them may also find opportunities to switch from oil to natural gas.

There are opportunities in the transportation sector to substitute natural gas or electricity for oil. Data from other countries show that the penetration rate of natural gas in the transportation services sector is higher than in North

America, and the EIA scenario indicates that it is likely to continue to increase in the United States. Electricity is also likely to become a source of energy for the transportation of goods. The survey results suggest that some Canadian firms are also exploring these possibilities. The Panel also expects greater penetration of natural gas in electricity production.

The oil and gas sector will be able to leverage higher energy prices to strengthen its competitive advantage, and there will be opportunities for firms that provide goods and services to this sector. The continued lower price of natural gas, relative to oil, will also benefit the Canadian chemical manufacturing industry. Increased availability of natural gas in North America suggests that industries that use natural gas (as either energy or feedstock) will have a competitive advantage. Many of the technologies employed in the oil sands industry make intensive use of natural gas.

Firms also well equipped to leverage higher energy prices are those producing energy-efficient equipment and systems. The firms making such products are likely to come from many manufacturing and service industries, and cannot be identified easily.

The Panel concluded that the challenges from higher energy prices are likely to be most serious for those firms using oil-based products, and with a limited ability to switch to other fuels. Manufacturing, which tends to use electricity and natural gas in the production process, will not be as directly affected as transportation services, for example, but the higher cost of transportation services will feed through to all firms moving products physically to market.

4. *How prepared are industry sectors and communities to capitalize on opportunities or mitigate risks that result from higher energy prices?*

Based on its review of the management and economic research, the Panel developed indicators of firm preparedness. These indicators include the availability of:

- timely, accurate, and relevant information about the evolution of energy markets;
- benchmarking data; and
- personnel specialized in understanding the implications of energy developments for the firm.

The Panel relied on its survey findings to draw conclusions about the preparedness of firms based on these indicators. The Panel found that 63% of survey respondents met the criterion of at least one indicator of preparedness. The vast majority of these had access to information about energy markets. About 25% of respondents met the criteria of at least two indicators and only 5% of respondents met all three.

On a sectoral basis, the sectors that exhibit the highest degree of preparedness — in the sense of meeting the criteria of at least two of the three indicators — are oil and gas production, electricity production, and transportation services. Firms in these sectors, among the eight sectors identified as exposed to energy prices, are at least twice as likely as those in other sectors to meet all three indicators (with the proportions ranging from 10 to 14%). However, it would appear that there were greater differences in the degree of preparedness within each sector rather than across sectors.

Analysis of the survey results suggests that there is a link between these indicators and changing strategy in response to energy price changes. While 43% of firms surveyed had changed strategy in response to the 2008 price increases and higher volatility, this proportion increased to 63% of firms with access to timely, accurate, and relevant information, and 60% of firms with benchmarking information. Causality is unclear. Do firms intending to change strategy seek information and dedicated staff, or do firms with information and dedicated staff learn that they should change strategy? However, what does seem clear is that being prepared through having accurate and timely information and access to dedicated staff would be an advantage if energy prices were to change.

Overall, the survey data suggest that there is an opportunity for many Canadian firms to become better prepared for a future of high and volatile energy prices by having specialized personnel and accessing better and timelier information, which is becoming more important for business decision-making. The Panel identified three types of information that could be particularly useful for firms:

1. **Benchmarking data** provide information on potential energy efficiency improvements that plants could undertake. The evidence examined by the Panel suggests that these data are particularly important as firms improve their operations in response to changing energy markets. Developing this type of information, however, relies on accessing commercially sensitive processes within firms, and would need to be produced by industry associations or private-sector consultants, rather than government.
2. **Sector-level data** provide information on the performance and adjustment of sectors to changing energy prices. If available on a comparable and timely basis internationally, they would give insights into how sectors adjust. Since

these data are public goods, they would have to be provided by government agencies such as Statistics Canada with consistent methodologies developed across countries by the OECD and the IEA.

3. **Price projections on energy prices** provide businesses insights into the forces likely to affect their costs, and suggest opportunities that could be exploited. Unprompted, many firms in the Panel's survey said that they relied on the EIA in the United States for such information. However, energy prices in Canada are likely to diverge from those in the United States for many important types of energy, notably electricity. The Panel is unaware of any consistent and comprehensive forecast of Canadian energy prices.

7.3 FINAL REFLECTIONS

Overall, the evidence reviewed by the Panel shows that Canadian firms have to date adapted successfully to past changes in energy prices. Higher and more volatile energy prices have not appeared to threaten the competitiveness of sectors exposed to higher energy prices, although there have undoubtedly been adjustments within sectors with resources moving from less energy-efficient firms to more energy-efficient firms. Adjusting to energy price shocks has traditionally entailed investing in more energy-efficient equipment and improving business processes. In future, however, the complexity of energy markets may mean that a different type of adjustment will be needed.

In interpreting this evidence, it must be recognized that energy prices, while important, are only one element in complex business decisions. Firms react on the basis of their information and their options. A compelling conclusion of the Panel's work is that there is a link between having good and timely information and the ability to act. Firms that are exposed to energy price increases or volatility can improve their preparedness to act by investing in information, including benchmarking information, and specialized resources focused on the financial and technical implications of energy prices for their business.

After reviewing the evidence, and exploring firms' behaviour through the survey, the Panel developed a heightened appreciation of how the challenges and opportunities facing business are likely to become more complex as energy markets evolve over the next decade and beyond. One aspect of this complexity is the emergence of new firms and industries that improve the use of energy. Solar panels are produced by the semiconductor industry, software firms are involved in "smart grid" developments, and electric-powered and driverless cars are being developed using the skills, knowledge, and entrepreneurial flair of Silicon Valley. Although there are Canadian success stories in these

industries, this type of broader adjustment has not been an area in which the Canadian economy overall has excelled, as discussed in many previous Council of Canadian Academies reports (as synthetized in CCA, 2013a).

Although the Panel was aware of these issues, they were areas that either were not within the scope of its charge or for which evidence was not readily available. They are nonetheless issues that are likely to become increasingly important in the future and worthy of further research. In particular, the Panel believes it would be helpful to explore the following in more depth:

- the impacts of new technologies on energy choices, in particular those related to the ability to substitute away from oil to electricity or natural gas in transportation, but also those that can mitigate the environmental and safety concerns in developing fossil fuels;
- the opportunities for Canadian firms through development of alternative sources of energy and new ways of using energy;
- the implications for Canada of greater energy abundance in the United States, such as the prospects for export markets and the competitiveness of energy-intensive firms in the United States versus Canadian competitors; and
- the specific information, data, and skill sets needed for business to adjust to and capitalize on a more complex energy future, the barriers to gathering and accessing such information and skill sets, and potential strategies to eliminate such barriers.

Appendix: Questionnaire

Appendix: Questionnaire

SURVEY OF CANADIAN FIRMS

Survey Questions

Council of Canadian Academies
Questionnaire

Hello, my name is _____ and I work for EKOS Research Associates. We are conducting a survey for the Council of Canadian Academies, an independent not-for-profit organization that undertakes studies of major public policy issues. The Federal Minister of Industry has asked the Council to undertake a study of Canadian Industry's Competitiveness in Terms of Energy Use, in order to understand how energy prices affect industry competitiveness by sector. The results of this comprehensive study are expected to inform public policy decisions.

As part of its study the Council is undertaking a survey of Canadian firms to understand how they are affected by energy prices and the impact of changing energy prices on business decision-making. We are interested in both energy as an input to business costs, and how energy prices may affect the demand for your products. Our aim is to understand both the challenges and opportunities your firm faces as energy prices evolve.

This survey is expected to take about 15 minutes, and your responses will be completely anonymous.

QUESTIONS

General Information About the Firm

Before we begin the survey, we would like to ask you a few general questions about your firm.

[Ask interviewer to note the corporate title (for example, Chief Executive Officer, Chief Financial Officer) of the interviewee.]

1. **How many years has your firm been in operation?** _____

2. **In which provinces does your firm operate?**

3. **Where is the location of your head office?**

4. **Is your firm:**

❒ Publicly traded	❒ Privately held	❒ A wholly-owned subsidiary of a foreign company

5. **Approximately what proportion of your production do you export?**

6. **Approximately how many full time employees are currently employed in your firm in Canada?**

Information About Energy Use

The next set of questions is about energy use and the impacts of changing energy prices in ***your Canadian operations****.*

7. How important is controlling energy costs as part of maintaining the overall competitiveness of your firm? Please use a 5-point scale where 1 means not at all important and 5 means extremely important.

Extremely Important				Not at all Important
5	4	3	2	1
❐	❐	❐	❐	❐

8. Approximately what proportion of your operating costs are energy costs?

9. As a share of operating costs, have your energy costs fallen, risen or stayed about the same over the past five years?

❐	Fallen	❐	Stayed about the same	❐	Risen

10. In order of importance, which energy sources have the greatest impact on your operations?

[READ LIST – MOST IMPORTANT FIRST].

	Greatest Impact (Select only one)	2nd Greatest Impact (Select only one)	3rd Greatest Impact (Select only one)
Oil products	❐	❐	❐
Natural gas	❐	❐	❐
Electricity	❐	❐	❐

11. Do energy costs mostly impact your firm through higher direct energy purchase costs, higher costs of other purchased inputs, or a change in demand for your products or services?

[Branch based on answer to Q11]

IF HIGHER DIRECT ENERGY COSTS OR HIGHER COSTS OF OTHER PURCHASED INPUTS:

Q 11.A.1: Please indicate the main uses of energy in your operations

[READ LIST: CHECK ALL THAT APPLY.]

- ❒ Heat and light
- ❒ Operation of equipment
- ❒ Transportation
- ❒ Feedstock
- ❒ Other (please specify)

Q 11.A.2 Of these, which is the main use of energy in your operations?

IF CHANGE IN DEMAND FOR PRODUCTS OR SERVICES

Q11.B.1 When faced with higher energy prices, do you generally experience an increase or a decrease in the demand for your products or services?

- ❒ Increase
- ❒ Decrease

Q11.B.2 In response to changing energy prices, do you change your product mix?

❒ Yes	❒ No	❒ Don't know/ No Response

Q11.B.3 [IF YES TO Q11.B.2] How quickly are you able to change your product mix?

[READ LIST: CHECK ONE]

❒ Within 1 month	❒ Within 6 months
❒ Within 1 year	❒ Other (please specify)

ASK ALL

Decision-Making Related to Energy Price Changes

The following questions relate to how decisions related to energy are made in the firm

12. Around 2008 we saw a marked increase in volatility in the price of oil and gas. Did your firm make any changes in strategy or operations to cope with increased volatility?

❒ Yes	❒ No	❒ Don't know/ No Response

[IF YES] What did you do? [OPEN]

13. Do you have staff at your firm whose official job description includes financial or economic analysis related to the impact of energy prices on the firm?

❒ Yes	❒ No	❒ Don't know/ No Response

14. How often are energy prices or costs discussed at meetings of senior management?

❒ Always	❒ Often	❒ Sometimes
❒ Rarely	❒ Never	

15. Where do you get your information about likely future energy price changes?

[OPEN – DO NOT READ – ACCEPT UP TO 3 RESPONSES]

❒	News reports
❒	Information from energy suppliers
❒	Internal forecasts from within your organization
❒	Forecasts from international organizations such as the EIA or OECD
❒	Forecasts from industry associations
❒	Common sense
❒	Word of mouth
❒	Other (specify)
❒	We don't make predictions about energy price changes

16. Has your firm adopted any of the following strategies in relation to energy prices?

[READ LIST – CHECK ALL THAT APPLY]

❒	Linking executive compensation to sustainability/energy goals
❒	Hedging energy costs
❒	Changing products
❒	Establishing a long-term agreement for fuel prices
❒	Acquiring strategic operations
❒	Relocating within the country or internationally. (Why?: To minimize production costs or transportation costs?)
❒	Developing your own energy sources

17. Do you have information that allows you to benchmark your energy efficiency against your competitors?

❒	Yes	❒	No	❒	Don't know/ No Response

18. [IF YES TO QUESTION 17] Where do you get that information?

[READ LIST]

❒ Industry association	❒ Special studies	❒ Trade press
❒ Other (specify)		

19. How does your firm compare in energy efficiency with your competitors? Please use a 5 point scale where 1 means much less energy efficient and 5 means much more energy efficient.

Extremely Important				Not at all Important
5	4	3	2	1
❒	❒	❒	❒	❒

20. Are you aware of energy efficiency measures taken by your main competitors?

❒ Yes	❒ No	❒ Don't know/ No Response

Technical Changes Related to Energy Use

The following questions relate to technical or engineering changes in your firm as a result of energy price changes.

21. Do you have a staff person whose official job description includes technical analysis related to energy use options in your firm?

❒ Yes	❒ No	❒ Don't know/ No Response

22. [IF YES TO 21] What is your estimate of the percentage of time that individual devotes to energy management?

23. Do energy management considerations play a large role in managing your supply chain?

❒ Yes	❒ No	❒ Don't know/ No Response

24. Which of the following technical changes have you made in the last five years to manage your firm's energy costs? [READ LIST]

- ❒ Fuel switching
- ❒ More energy-efficient equipment (refrigeration, heat, lighting, manufacturing equipment)
- ❒ Relocating operations
- ❒ Changing suppliers of inputs
- ❒ Other (specify)
- ❒ No technical changes made

[IF YES TO ANY OF THE ABOVE]

25. What motivated these changes?

[OPEN – DO NOT READ - ACCEPT UP TO 3 RESPONSES]

- ❒ Government incentives
- ❒ In response to changing energy prices
- ❒ Old equipment coming to end of use
- ❒ To improve competitiveness
- ❒ Policy or regulations
- ❒ Maintain production levels
- ❒ Budget concerns
- ❒ Profit motives
- ❒ Environmental concerns
- ❒ Changing suppliers of inputs
- ❒ Other (specify)

26. Do you anticipate making any of the following changes related to energy use in the next 10 years? [READ LIST]

❒	Fuel switching
❒	More energy-efficient equipment (refrigeration, heat, lighting, manufacturing equipment)
❒	Changing suppliers of inputs
❒	Relocating operations
❒	Other (specify)

Regulatory or Policy Impacts on Realizing Opportunities or Mitigating Risks

The next questions ask about programs or policies that have had an impact on your ability to make energy-related changes.

27. Are there policies or programs that have helped you to make energy efficiency changes?

❒	Yes	❒	No	❒	Don't know/ No Response

[IF YES]

28. Which programs have worked best for you?

[OPEN]

29. Are there policy or regulatory constraints that make it difficult for you to mitigate the risks to your operations from higher or more volatile energy prices?

❒	Yes	❒	No	❒	Don't know/ No Response

[IF YES TO Q29]

30. What are the constraints?

[OPEN]

31. Do higher or more volatile energy prices provide potential opportunities for your firm?

❒ Yes	❒ No	❒ Don't know/ No Response

[IF YES TO Q31]

32. Please describe the opportunities.

[OPEN]

[IF YES TO Q31]

33. Are there regulatory or policy constraints to realizing the opportunities?

❒ Yes	❒ No	❒ Don't know/ No Response

[IF NO TO Q 31]

34. Are there other firms in your supply chain that could realize potential opportunities from more volatile energy prices?

❒ Yes	❒ No	❒ Don't know/ No Response

Response to Scenarios

The last set of questions in the survey relates to decision-making in response to different energy price scenarios.

35. Looking out to 2025, if [OIL/GAS/ELECTRICITY depending on answer to question 10] rose by 20%, what would be the impact on your firm? [OPEN]

36. Looking out to 2025, if [OIL/GAS/ELECTRICITY depending on answer to question 10] decreased by 20%, what would be the impact on your firm? [OPEN]

The Panel is interested in identifying people who would be willing to be considered to take part in a focus group or more detailed interviews. Would you be willing to be considered for this? If yes, please tell us your name and telephone number (or email address if you prefer).

References

References

ACC (American Chemistry Council). (2011). *Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing*. Washington (DC): American Chemistry Council.

Adès, J., Bernard, J.-T., and González, P. (2012). Energy Use and GHG Emissions in the Quebec Pulp and Paper Industry, 1990-2006. *Canadian Public Policy, 38*(1), 71-90.

Airbus. (2013a). Reaching new heights in fuel efficiency. Retrieved May 2013, from http://www.a350xwb.com/#eco-efficient/greener/.

Airbus. (2013b). Eco-efficiency at every step of the aircraft life-cycle. Retrieved May 2013, from http://www.airbus.com/innovation/eco-efficiency/operations/alternative-fuels/.

Airbus. (2013c). Airbus and Sustainable Aviation. Retrieved May 2013, from http://www.airbus-fyi.com/article/215.

Alcoa. (2013). Energy Efficiency. Retrieved May 2013, from http://www.alcoa.com/sustainability/en/info_page/resources_energy.asp.

Allcott, H. & Mullainathan, S. (2010). Behavior and energy policy. *Science, 327*, 1204-1205.

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics, 95*(9/10), 1082-1095.

Allcott, H. & Greenstone, M. (2012). Is there an energy efficiency gap? *Journal of Economics Perspectives 26*(1), 3-28.

Almon, M.-J. & Tang, J. (2011). Industrial structural change and the post-2000 output and productivity growth slowdown: A Canada-U.S. Comparison. *International Productivity Monitor, 22*, 44-81.

Australian Government. (2012). *Alcoa Pinjarra – Industry Leader Case Study*. Canberra, Australia: Department of Resources, Energy, and Tourism.

BEA (Bureau of Economic Analysis). (2013). *GDP by Industry, KLEMS Accounts*. Washington (DC): Bureau of Economic Analysis.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics, 98*(1), 85-106.

Bertrand, M. & Mullainathan, S. (2001). Do people mean what they say? Implications for subjective survey data. *American Economic Review, 9*(2), 67-72.

Black, S. E., and Lynch, L.M. (2001). How to compete: The impact of workplace practices and information technology on productivity. *Review of Economics and Statistics, 83*(3), 434-445.

Bloom, N. & Van Reenen, J. (2007). Measuring and explaining management practices across firms and countries. *The Quarterly Journal of Economics, 122*(4), 1351-1408.

Bloom, N., Genakos, C., Martin, R., & Sadun, R. (2010). Modern management: Good for the environment or just hot air? *The Economic Journal, 120*(544), 551-572.

Boeing. (2013). Long-term Market Business Environment. Retrieved May 2013, from http://www.boeing.com/boeing/commercial/cmo/business_environment.page.

Borenstein, S. (2012). The private and public economies of renewable electricity generation. *The Journal of Economic Perspectives, 26*(1), 67-92.

BP. (2013). *BP Statistical Review of World Energy 2013*. London, United Kingdom: BP.

Bresnahan, T. F., and Ramey, V.A.,. (1993). Segment shifts and capacity utilization in the U.S. automobile industry. *American Economic Review, 83*(213-218).

Bunse, K., Vodicka, M., Schönsleben, P., Brulhart, M., & Ernst, F. O. (2011). Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *Journal of Cleaner Production*, 19, 667-679. doi: 10.1016/j.jclepro.2010.11.011

Bunse, K., Sachs, J., & Vodicka, M. (2010). Evaluating Energy Efficiency Improvements in Manufacturing Processes. In B. Vallespir & T. Alix (Eds.), *Advances in Production Management Systems: New Challenges, New Approaches*. Center for Enterprise Sciences, Zurich, Switzerland: IFIP International Federation for Information Processing. Bresnahan, T. F., and Ramey, V.A., (1993). Segment shifts and capacity utilization in the U.S. automobile industry. *American Economic Review, 83*(213-218).

Burstein, F., Brézillon, P., & Zaslavsky, A. (2011). *Supporting Real Time Decision-making*. New York (NY): Springer.

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

CCA (Council of Canadian Academies). (2013a). *Paradox Lost: Explaining Canada's Research Strength and Innovation Weakness*. Ottawa (ON): Council of Canadian Academies.

CCA (Council of Canadian Academies). (2013b). *Innovation Impacts: Measurement and Assessment. The Expert Panel on the Socioeconomic Impacts of Innovation Investments*. Ottawa (ON): Council of Canadian Academies.

CCA (Council of Canadian Academies). (2013c). *The State of Industrial R&D in Canada. The Expert Panel on Industrial R&D in Canada*. Ottawa (ON): Council of Canadian Academies.

CCA (Council of Canadian Academies). (2014). *Environmental Impacts of Shale Gas Extraction in Canada*. Ottawa (ON): Council of Canadian Academies.

Celasun, O., Di Bella, G., Mahedy, T., & Papageorgiou, C. (2014). *The U.S. Manufacturing Recovery: Uptick or Renaissance? IMF Working Paper*. Washington (DC): International Monetary Fund.

CEPA (Canadian Energy Pipeline Association). (2013). Liquids Pipelines. Retrieved April 2014, from http://www.cepa.com/map/index-en.html.

Chakravorty, U., Roumasset, J., & Tse, K. (1997). Endogenous substitution among energy resources and global warming. *The Journal of Political Economy, 105*(6), 1201-1234.

Cleveland, C. J. (2007). Energy Quality, Net Energy, and the Coming Energy Transition. In J. D. Erickson & J. M. Gowdy (Eds.), *Frontiers in Ecological Economic Theory and Application*. Northampton (MA): Edward Elgar.

Clewlow, L. & Strickland, C. (2000). *Energy Derivatives: Pricing and Risk Management* London, United Kingdom: Lacima Publications.

CN. (2012). CN Tests Natural Gas/Diesel Fuel Powered Locomotives Between Edmonton and Fort McMurray, Alta. Retrieved April 2014, from http://www.cn.ca/en/news/2012/09/media_news_cn_tests_natural_gas_locomotives_20120927.

Conway, P. & Nicoletti, G. (2007). Product market regulation and productivity convergence: OECD evidence and implications for Canada. *International Productivity Monitor, 15*, 3-24.

Davis, S. J. & Haltiwanger, J. (2001). Sectoral job creation and destruction responses to oil price changes. *Journal of Monetary Economics, 48*, 465-512.

DeCanio, S. J. (1998). The efficiency paradox: Bureaucratic and organizational barriers to profitable energy-saving investments. *Energy Policy, 26*(5), 441-454.

Decanio, S. J. & Watkins, W. (1998). Investment in energy efficiency: Do the characteristics of firms matter? *Review of Economics and Statistics 80*, 95-107.

Dhawan, R., and Jeske, K. (2006). *How Resilient Is the Modern Economy to Energy Price Shocks?* Atlanta (GA): Federal Reserve Bank of Atlanta, Economic Review (Third Quarter).

Dixit, A. K. & Pindyck, R. S. (1994). *Investment Under Uncertainty*. Princeton (NJ): Princeton University Press.

Dvir, E. & Rogoff, K. S. (2009). *Three Epochs of Oil*. Vol. No. 14927. Cambridge (MA): National Bureau of Economic Research Working Paper.

EIA (U.S. Energy Information Administration). (2006). *Annual Energy Outlook 2006*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2013a). *Annual Energy Outlook 2013*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2013b). *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014a). *U.S. Crude Oil and Natural Gas Proved Reserves, 2012*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014b). *International Energy Statistics*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014c). *Natural Gas Prices*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014d). *Natural Gas Spot and Futures Prices (NYMEX)*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014e). *Petroleum and Other Liquids, Spot Prices*. Washington (DC): EIA.

EIA (U.S. Energy Information Administration). (2014f). About EIA. Retrieved April 16, 2014, from http://www.eia.gov/about/mission_overview.cfm.

EIA (U.S. Energy Information Administration). (2014g). *Natural Gas Consumption by End Use*. Washington (DC): EIA.

Eichholtz, P., Kok, N., & Quigley, J. M. (2010). Doing well by doing good?: Green office buildings. *American Economic Review, 100*(5), 2494-2511.

Elder, J. & Serletis, A. (2010). Oil price uncertainty. *Journal of Money, Credit and Banking, 42*(6), 1137-1159.

Energent. (2013). CIPEC Industrial Energy Innocator Award Given to GM Canada. Retrieved June, 2013, from http://www.energent.com/news-events/cipec-industrial-energy-innovator-award-given-gm-canada.

Environment Canada. (2013). Canada Continues to Align Greenhouse Gas Emissions Measures with the United States. Retrieved November 2013, from http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=3FC39747-ABF2-470A-A99E-48CA2B881E97.

EPA (U.S. Environmental Protection Agency). (2013). Cuyahoga River. Retrieved April 16, 2014, from http://www.epa.gov/greatlakes/aoc/cuyahoga/.

Eurostat. (2007). Final Energy Consumption, by Sector. Retrieved May 2013, from http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,39140985&_dad=portal&_schema=PORTAL&screen=detailref&language=en&product=sdi_cc&root=sdi_cc/sdi_cc/sdi_cc_ene/sdi_cc2200.

Federal Reserve Bank of St. Louis. (2013). Federal Reserve Economic Data. Retrieved November 2013, from http://research.stlouisfed.org/fred2/.

Foote, C. L. & Little, J. S. (2011). *Oil and the Macroeconomy in a Changing World: A Conference Summary*. Vol. 11-3. Boston (MA): Federal Reserve Bank of Boston Public Policy Discussion Papers.

Fukunaga, I., Hirakata, N. and Sudo, N. (2011). The Effects of Oil Price Changes on the Industry-Level Production and Prices in the United States and Japan. In T. Ito, and Rose, A.K. (Eds.), *Commodity Prices and Markets, NBER Book Series East Asia Seminar on Economics, Volume 20*. Chicago (IL): University of Chicago Press.

Gillingham, K., Newell, R. G., & Palmer, K. (2009). Energy efficiency economics and policy. *Annual Review of Resource Economics, 1*(1), 597-619.

Goulding, A. J. (2013). *A New Blueprint for Ontario's Electricity Market*. Vol. No. 389. Toronto (ON): C.D. Howe Institute.

Greening, L. A., Greene, D. L., & Difiglio, C. (2000). Energy efficiency and consumption - the rebound effect - a survey. *Energy Policy, 28*(6-7), 389-401.

Hamilton, J. D. (2008). Oil and the Macroeconomy. In S. N. Durlauf & L. E. Blume (Eds.), *The New Palgrave Dictionary of Economics* (Second Edition) Hampshire, United Kingdom: Palgrave Macmillan.

Hamilton, J. D. (2009). Causes and consequences of the oil shock of 2007–08. *Brookings Papers on Economic Activity* (Spring), 215-283.

Hassler, J., Krussell, P., & Olovsson, C. (2012). *Energy-Saving Technical Changes*. Cambridge (MA): National Bureau of Economic Research Working Paper, w18456.

Hausman, J. A. (1979). Individual discount rates and the purchase and utilization of energy-using durables. *The Bell Journal of Economics 10*(1), 33-54.

Herrera, A. M., and Karaki, M. B. (2013). *The Effects of Oil Price Shocks on Job Reallocation*. Lexington (KY): University of Kentucky.

Hicks, J. R. (1932). *The Theory of Wages*. London, United Kingdom: Macmillan Publishers.

Hughes, J. E., Knittel, C.R., and Sperling, D. (2008). Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand. *Energy Journal, 29*(1), 113-134.

Hydro-Québec. (2010). *Plan d'approvisionnement, 2011-2020, Réseau Intégré*. Montréal (QC): Hydro-Québec.

Hydro-Québec. (2013). Comparison of Electricity Prices in Major North American Cities. Retrieved April 2014, from http://www.hydroquebec.com/publications/en/comparison_prices/pdf/comp_2013_en.pdf.

IAI (International Aluminium Institute). (2013). Primary Aluminum Production. Retrieved May 2013, from http://www.world-aluminium.org/statistics/.

IATA (International Air Transport Association). (2013). *Financial Forecast, June 2013*. Miami (FL): IATA.

IEA (International Energy Agency). (2013a). *Key World Energy Statistics, 2013*. Paris, France: International Energy Agency.

IEA (International Energy Agency). (2013b). Canada: Oil for 2010. Retrieved April 2014, from http://www.iea.org/statistics/statisticssearch/report/?&country=CANADA&year=2010&product=Oil.

IESO (Independent Electricity System Operator). (2014). Global Adjustment. Retrieved April 2014, from http://www.ieso.ca/Pages/Ontario%27s-Power-System/Electricity-Pricing-in-Ontario/Global-Adjustment.aspx.

Industry Canada. (2012). Key Small Business Statistics: How Many Businesses are There in Canada? Retrieved November 2013, from http://www.ic.gc.ca/eic/site/061.nsf/eng/02715.html.

Industry Canada. (2014a). Canadian Industry Statistics, Glossary of Terms. Retrieved April 2014, from http://www.ic.gc.ca/eic/site/cis-sic.nsf/eng/h_00005.html.

Industry Canada. (2014b). *Canadian Industry Statistics*. Ottawa (ON): Industry Canada.

Jacobsen, M. R. (2013). Evaluating U.S. fuel economy standards in a model with producer and household heterogeneity. *American Economic Journal: Economic Policy, 5*(2), 148-187.

Jacoby, H. D. & Sue Wing, I. (1999). Adjustment time, capital malleability, and policy cost. *Energy Journal, 20*(Special Issue: The Costs of the Kyoto Protocol: A Multi-Model Evaluation), 73-92.

Jaffe, A. B. & Stavins, R. N. (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics, 16*, 91-122.

Jevons, W. S. (1866). *The Coal Question (2nd ed.)*. London, United Kingdom: Macmillan and Co.

Johansson, B., Modig, G., & Nilsson, L. (2007). *Policy Instruments and Industrial Responses – Experiences from Sweden*. Paper presented at ECEE 2007 Summer Study.

Kaminski, V. (2004). *Managing Energy Price Risk: The New Challenges and Solutions, 3rd Edition*. London, United Kingdom: Risk Books.

Kilian, L. (2008). The economic effects of energy price shocks. *Journal of Economic Literature, 46*(4), 871-909.

Klier, T. & Linn, J. (2010). The price of gasoline and new vehicle fuel economy: Evidence from monthly sales data. *American Economic Journal: Economic Policy, 2*(3), 134-153.

Knittel, C. R. (2012). Reducing petroleum consumption from transportation. *Journal of Economic Perspectives, 26*(1), 93-118.

Krupnick, A. J. (2012). Will natural gas vehicles be in our future? *Resources Magazine*, 181.

Lawrence, P. (2009). Meeting the challenge of aviation emissions: An aircraft industry perspective. *Technology Analysis & Strategic Management, 21*(1), 79-92.

Lee, J. J. (2010). Can we accelerate the improvement of energy efficiency in aircraft systems? *Energy Conversion and Management, 51*, 189-196.

Manitoba Hydro. (2013). Utility Rate Comparisons. Retrieved April 2014, from http://www.hydro.mb.ca/regulatory_affairs/energy_rates/electricity/utility_rate_comp.shtml.

Martin, R. (2010). *Why is the US So Energy Intensive? Evidence from US Multinationals in the UK*. London, United Kingdom: Centre for Economic Performance.

Martin, R., Muûls, M., de Preux, L. B., & Wagner, U. J. (2012). Anatomy of a paradox: Management practices, organizational structure and energy efficiency. *Journal of Environmental Economics and Management, 63*(2), 208-223.

Matzenberger, J. (2013). A novel approach to exploring the concept of resilience and principal drivers in a learning environment. *Multicultural Education & Technology Journal, 7*(2/3), 192-206.

McKane, A., Williams, R., Perry, W., & Li, T. (2007). *Setting the Standard for Industrial Energy Efficiency*. Berkeley (CA): Lawrence Berkeley National Laboratory.

McKinsey Global Institute. (2013). *Game Changers: Five Opportunities for US Growth and Renewal*. New York (NY): McKinsey Global Institute.

Miller, R. & Côté, M. (2012). *Innovation Reinvented: Six Games that Drive Growth*. Toronto (ON): Rotman-UTP Publishing.

Montana, P. J. & Charnos, B. H. (2008). *Management* (4th Ed.). New York (NY): Barron's Educational Series.

Moore, M. C., Turcotte, A., Winter, J., & Walp, P. B. (2013). Energy and energy literacy in Canada: A survey of business and policy leadership. *University of Calgary: The School of Public Policy, 6*(10).

Mulder, P., and de Groot, L. F. (2012). Structural change and convergence of energy intensity across OECD countries, 1970–2005. *Energy Economics, 34*(6), 1910-1921.

NEB (National Energy Board). (2013). The Regulation of Traffic, Tolls and Tariffs. Retrieved November 2013, from http://www.neb-one.gc.ca/clf-nsi/rthnb/whwrndrgvrnnc/rgltntrffctllstrffs2007-eng.html.

NERC & CAISO (The North American Electric Reliability Corporation and The California Independent System Operator Corporation). (2013). *2013 Special Reliability Assessment: Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources – CAISO Approach.* Atlanta (GA): NERC & CAISO.

Newell, R. G., Jaffe, A. B., & Stavins, R. N. (1999). The induced innovation hypothesis and energy-saving technological change. *The Quarterly Journal of Economics, 114*(3), 941-975.

Newell, R. G. & Iler, S. (2013). *The Global Energy Outlook.* Vol. No. 18967. Cambridge (MA): National Bureau of Economic Research Working Paper.

NOVA Chemicals. (2013). NOVA Chemicals Announces Plans for Multiple Projects in Sarnia Region. Retrieved February 2014, from http://www.novachem.com/Lists/News%20and%20Events/DispForm.aspx?ID=73&Source=http://www.novachem.com/Pages/news-events/news-releases.aspx&ContentTypeId=0x010400E53A6C6043F78B4DB6DFF97139CDA303.

NOVA Chemicals. (2014). Joffre Expansion Project. Retrieved February 2014, from http://www.novachem.com/Pages/company/joffre-expansion.aspx.

NRCan (Natural Resources Canada). (2013). Biomass, Bioenergy and Bioproducts: Wood Pellets. Retrieved November 2013, from http://cfs.nrcan.gc.ca/pages/402.

NRCan (Natural Resources Canada). (2011). *Making Energy Visible.* Ottawa (ON): NRCan.

NRCan (Natural Resources Canada). (2008). *Benchmarking Energy Use in Canadian Pulp and Paper Mills.* Ottawa (ON): NRCan.

NRCan (Natural Resources Canada). (2007). *Benchmarking Energy Intensity in the Canadian Steel Industry.* Ottawa (ON): NRCan.

OECD (Organisation for Economic Co-operation and Development). (2012). *OECD Economic Surveys: Canada 2012*. Paris, France: OECD Publishing

OECD (Organisation for Economic Co-operation and Development). (2014). *Green Growth Indicators*. Paris, France: OECD.

OECD/IEA (Organisation for Economic Co-operation and Development / International Energy Agency). (2007). *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency*. Paris, France: International Energy Agency.

Ottosson, C. & Petersson, K. (2007). *First Results from the Swedish LTA Programme for Energy Efficiency in Industry*. Paper presented at ECEE 2007 Summer Study.

Partners in Project Green. (2009). Ontario Truckers Keen on Green. Retrieved June 2014, from http://www.partnersinprojectgreen.com/news/192-ontario-truckers-keen-on-green.

Pearce, B. (2012). The state of air transport markets and the airline industry after the great recession. *Journal of Air Transport Management, 21*, 3-9.

Pineau, P.-O. (2012). The Price of Electricity in Québec: Reconciling Conflicting Views. In S. Savard & M. Pâquet (Eds.), *Energy and Citizenship in Quebec*. Montréal (QC): Consortium Érudit.

Popp, D. (2002). Induced innovation and energy prices. *The American Economic Review, 92*(1), 160-180.

Popp, D. (2006). International innovation and diffusion of air pollution control technologies: The effects of NO_X and SO_2 regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management, 51*(1), 46-71.

Popp, D., Newell, R. G., & Jaffe, A. B. (2010). Energy, the Environment, and Technological Change. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation* (Vol. 2). Amsterdam, North Holland: Academic Press.

Probst, K. N. & Szambelan, S. J. (2009). The role of the states in a federal climate program: Issues and options. *Resources for the Future: Discussion Papers, RFF DP 09-46*, 1-23.

Ramey, V., and Vine, D.J. (2010). Oil, Automobiles and the U.S. Economy: How Much Have Things Really Changed? *NBER Macroeconomics Annual 2010*.

Rohdin, P., Thollander, P., & Solding, P. (2007). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy, 35*(1), 672-677.

Sanstad, A., Hanemann, M., & Auffhammer, M. (2006). *End-use Energy Efficiency in a "Post-Carbon" California Economy: Policy Issues and Research Frontiers*. Berkley (CA): UC-Berkeley.

SASOL Canada. (2012). *The Canada GTL Project.* Calgary (AB): SASOL.

SCBC (Supreme Court of British Columbia). (2012). *Unlu vs. Air Canada.* Vancouver (BC): SCBC.

Schipper, L., Howarth, R. B., & Geller, H. (1990). United States energy use from 1973 to 1987: The impacts of improved efficiency. *Annual Review of Energy, 15*, 455-504.

Schrag, D. (2009). Coal as a low-carbon fuel? *Nature Geoscience, 2*, 818-820.

SFI (Swedish Forest Industries). (2011). *The Swedish Forest Industries – Facts and Figures 2011.* Stockholm, Sweden: SFI.

Sharpe, A. & Long, B. (2012). *Innovation in Canadian Natural Resource Industries: A Systems-Based Analysis of Performance, Policy and Emerging Challenges.* Ottawa (ON): Centre for the Study of Living Standards.

Shogren, J. & Taylor, L. (2008). On behavioral-environmental economics. *Review of Environmental Economics and Policy, 2*(1), 26-44.

Statistics Canada. (2012). *Energy Statistics Handbook (First quarter 2012).* Vol. 57-601-X. Ottawa (ON): Statistics Canada.

Statistics Canada. (2014a). *CANSIM Table 153-0032.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014b). *CANSIM Table 383-0011.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014c). *CANSIM Table 128-0009.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014d). *CANSIM Table 379-0025.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014e). *CANSIM Table 127-0007.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014f). *CANSIM Table 383-0011.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014g). *CANSIM Table 383-0022.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014h). *CANSIM Table 379-0031.* Ottawa (ON): Statisitcs Canada.

Statistics Canada. (2014i). The Canadian Centre for Data Development and Economic Research (CDER). Retrieved April 2014, from http://www.statcan.gc.ca/cder-cdre/.

Statistics Canada. (2014j). *CANSIM Table 128-0006.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014k). *CANSIM Table 380-0083.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014l). *CANSIM Table 380-0084.* Ottawa (ON): Statistics Canada.

Statistics Canada. (2014m). *CANSIM Table 051-0001.* Ottawa (ON): Statistics Canada.

Steinbuks, J. (2012). Interfuel substitution and energy use in the U.K. manufacturing sector. *The Energy Journal, 33*(1), 1-29.

Summers, L. H. (2009). *Remarks by Lawrence H. Summers at the Brookings Institution.* Washington (DC).

Syverson, C. (2011). What determines productivity? *Journal of Economic Literature, 49*(2), 326-365.

Szodruch, J., Grimme, W., Blumrich, F., & Schmid, R. (2011). Next generation single-aisle aircraft – Requirements and technological solutions. *Journal of Air Transport Management, 17*, 33-39.

The Economist. (2013, July 27). Australia's Gas Explorers (I): The Next Qatar? *The Economist.*

Thollander, P. & Ottosson, M. (2008). An energy efficient Swedish pulp and paper industry – Exploring barriers to and driving forces for cost-effective energy efficiency investments. *Energy Efficiency 1*(1), 21-34.

Thollander, P. & Ottosson, M. (2009). *Exploring Energy Management in the Swedish Pulp and Paper Industry*. Paper presented at ECEEE 2009 Summer Study.

Thollander, P. & Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production, 18*, 1125-1133.

Turrentine, T. S. & Kurani, K. S. (2007). Car buyers and fuel economy? *Energy Policy, 35*(2), 1213-1223.

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy, 28*(12), 817-830.

Unruh, G. C. (2002). Escaping carbon lock-in. *Energy Policy, 30*(4), 317-325.

USGS (U.S. Geological Survey). (2008). 90 Billion Barrels of Oil and 1,670 Trillion Cubin Feet of Natural Gas Assessed in the Arctic. Retrieved December 2013, from http://www.usgs.gov/newsroom/article.asp?ID=1980&from=rss_home.

van de Ven, D.-J., and Fouquet, R. (2014). *Historical Energy Price Shocks and their Changing Effects on the Economy*. London, United Kingdom: Centre for Climate Change Economics and Policy, Working Paper No. 171 and Grantham Research Institute on Climate Change and the Environment, Working Paper No. 153.

Weitzman, M. L. (2009). On modeling and interpreting the economics of catastrophic climate change. *The Review of Economics and Statistics, 91*(1), 1-19.

Wising, U., Berntsson, T., & Stuart, P. (2005). The potential for energy savings when reducing the water consumption in a Kraft Pulp Mill. *Applied Thermal Engineering, 25*(77), 1057-1066.

Wolfram, C., Shelef, O., & Gertler, P. (2012). How will energy demand develop in the developing world? *Journal of Economic Perspectives, 26*(1), 119-138.

Yeh, S. (2007). An empirical analysis on the adoption of alternative fuel vehicles: The case of natural gas vehicles. *Energy Policy, 35*, 5865-5875.

Assessments of the Council of Canadian Academies

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

- Energy Prices and Business Decision-Making in Canada: Preparing for the Energy Future (2014)
- Improving Medicines for Children in Canada (2014)
- Science Culture: Where Canada Stands (2014)
- Enabling Sustainability in an Interconnected World (2014)
- Environmental Impacts of Shale Gas Extraction in Canada (2014)
- Aboriginal Food Security in Northern Canada: An Assessment of the State of Knowledge (2014)
- Ocean Science in Canada: Meeting the Challenge, Seizing the Opportunity (2013)
- The Health Effects of Conducted Energy Weapons (2013)
- The State of Industrial R&D in Canada (2013)
- Innovation Impacts: Measurement and Assessment (2013)
- Water and Agriculture in Canada: Towards Sustainable Management of Water Resources (2013)
- Strengthening Canada's Research Capacity: The Gender Dimension (2012)
- The State of Science and Technology in Canada, 2012 (2012)
- Informing Research Choices: Indicators and Judgment (2012)
- Integrating Emerging Technologies into Chemical Safety Assessment (2012)
- Healthy Animals, Healthy Canada (2011)
- Canadian Taxonomy: Exploring Biodiversity, Creating Opportunity (2010)
- Honesty, Accountability, and Trust: Fostering Research Integrity in Canada (2010)
- Better Research for Better Business (2009)
- The Sustainable Management of Groundwater in Canada (2009)
- Innovation and Business Strategy: Why Canada Falls Short (2009)
- Vision for the Canadian Arctic Research Initiative: Assessing the Opportunities (2008)
- Energy from Gas Hydrates: Assessing the Opportunities and Challenges for Canada (2008)
- Small Is Different: A Science Perspective on the Regulatory Challenges of the Nanoscale (2008)
- Influenza and the Role of Personal Protective Respiratory Equipment: An Assessment of the Evidence (2007)
- The State of Science and Technology in Canada (2006)

The assessments listed below are in the process of expert panel deliberation:

- The Future of Canadian Policing Models
- Memory Institutions and the Digital Revolution
- Wind Turbine Noise and Human Health
- STEM Skills for the Future
- The Potential for New and Emerging Technologies to Reduce the Environmental Impacts of Oil Sands Development
- RISK: Is the Message Getting Through?
- Timely Access to Health and Social Data for Health Research and Health System Innovation

Board of Governors of the Council of Canadian Academies*

* Affiliations as of June 2014

Scientific Advisory Committee of the Council of Canadian Academies*

Susan A. McDaniel, FRSC, Chair, Director, Prentice Institute & Canada Research Chair in Global Population & Life Course, Prentice Research Chair & Professor of Sociology, University of Lethbridge (Lethbridge, AB)

Lorne Babiuk, O.C., FRSC, FCAHS, Vice President (Research), University of Alberta (Edmonton, AB)

Murray S. Campbell, Senior Manager, Business Analytics Research, IBM T.J. Watson Research Center (Yorktown Heights, NY)

Clarissa Desjardins, Former CEO, Centre of Excellence in Personalized Medicine (Montréal, QC)

Jean Gray, C.M., FCAHS, Professor of Medicine (Emeritus), Dalhousie University (Halifax, NS)

John Hepburn, FRSC, Vice President, (Research and International), University of British Columbia (Vancouver, BC)

Gregory S. Kealey, FRSC, Professor, Department of History, University of New Brunswick (Fredericton, NB)

Daniel Krewski, Professor of Epidemiology and Community Medicine and Scientific Director of the McLaughlin Centre for Population Health Risk Assessment, University of Ottawa (Ottawa, ON)

Avrim Lazar, Former President and CEO, Forest Products Association of Canada (Ottawa, ON)

Norbert Morgenstern, C.M., FRSC, FCAE, University Professor (Emeritus), Civil Engineering, University of Alberta (Edmonton, AB)

Sarah P. Otto, FRSC, Professor and Director of the Biodiversity Research Centre, University of British Columbia (Vancouver, BC)

*Affiliations as of June 2014

Council of Canadian Academies
Conseil des académies canadiennes

Council of Canadian Academies
180 Elgin Street, Suite 1401
Ottawa, ON K2P 2K3
Tel: 613-567-5000
www.scienceadvice.ca