ECONOMIC IMPACT OF UTILIZATION OF LIQUEFIED NATURAL GAS (LNG) IN THE PROVINCE OF NEW BRUNSWICK

by
Xiaochen Zhou

B.Sc., University of Prince Edward Island, Canada, 2013

A Report Submitted in Partial Fulfillment
of the Requirements for the Degree of

Master of Arts in Economics

in the Graduate Academic Unit of Economics

Supervisor: Yuri V. Yevdokimov, Ph.D., Department of Economics and Civil Engineering

Examining Board:

Michael G. Farnworth, Ph.D., Department of Economics, Chair
Mehmet Dalkir, Ph.D., Department of Economics
Philip Leonard, Ph.D., Department of Economics

This report is accepted by the
Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

August 2015

ABSTRACT

In this study, economic impact of liquefied natural gas (LNG) utilization in the province of New Brunswick is analyzed and quantified. First, major economic consequences of LNG utilization for provincial economy are identified. Second, a dynamic demand/supply model of natural gas sector is designed and estimated. Third, the designed model is used to simulate cumulative economic impact of LNG utilization in the province. Finally, simulated data is used to calculate annual long-run increase in value added, tax revenue and job creation due to a one percent increase in LNG utilization in the province of New Brunswick.

DEDICATION

I dedicate my work to my family, professors and friends who have been there for me throughout the entire study. A special gratitude to my parents who provide me the selfless financial support, so I have a chance to be an international student at university of New Brunswick.

ACKNOWLEDGEMENTS

I would like to express my very great appreciation to Dr.Yuri Yevdokimov, my supervisor, for his encouragement, patient guidance and useful critiques of this study. As a beginner in the field of economic analysis, I have met lots of challenges during this study and Dr. Yuri Yevdokimov has always guided me patiently. Moreover, his deep knowledge and practical advice have inspired me throughout my study. I am also grateful for assistance given by Yunlu Liu and Dmitry Shcherbakov, graduate students in economics at UNB, for their help in collecting data and estimating my model. I also send very warm regards to Dr. Mehmet Dalkir and Dr. Philip Leonard and other professors in the Department of Economics at UNB who were teaching me and are reading this report.

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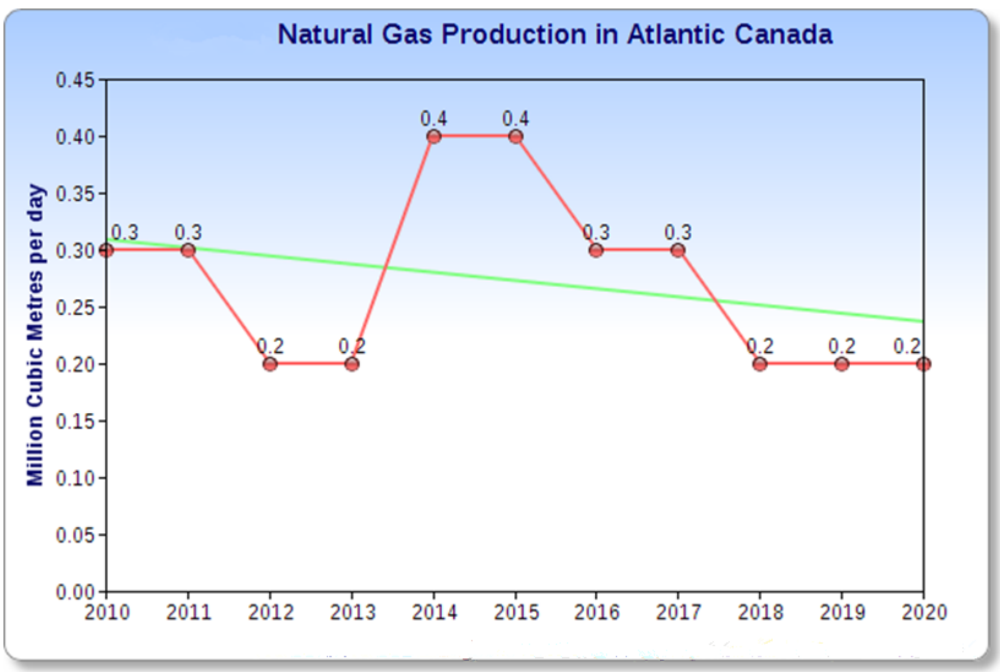
Introduction

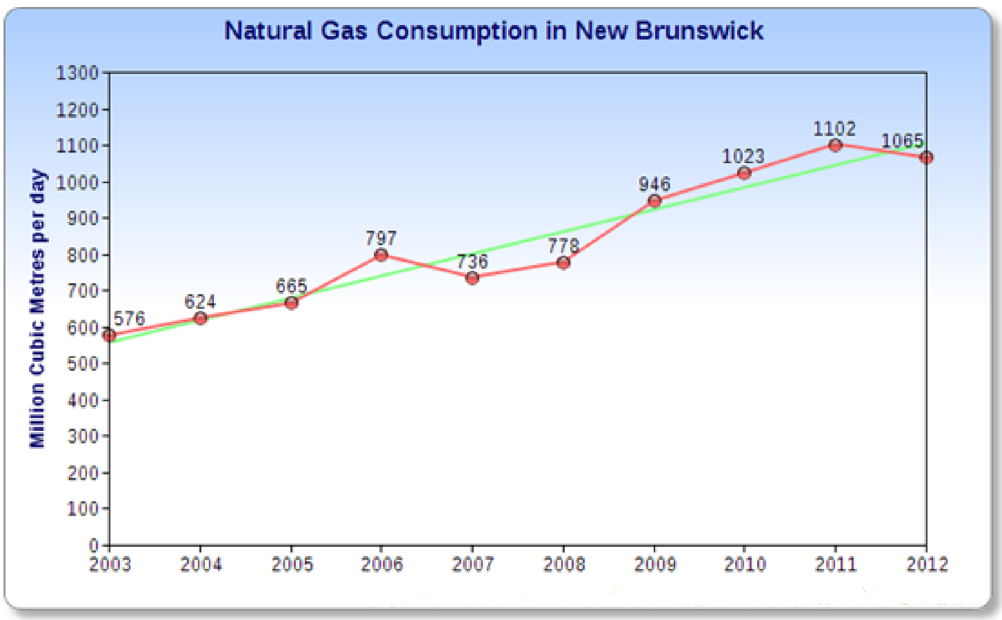
Supply of natural gas in Atlantic Canada has been declining for several years. Moreover, in accordance with the forecast of National Energy Board, it will continue to decline in the short run (Figure 1). On the other hand, the National Energy Board also predicts that demand for natural gas in Atlantic Canada will grow in the long run (Figure 2), and the share of natural gas demanded by residential sector, commercial sector, industry and transportation will gradually expand in the future.

Figure 1: Natural Gas Production in Atlantic Canada, data collected from Canada's Energy Future 2013: Supply and Demand Projections to 2035.



With regard to the province of New Brunswick, its natural gas consumption increased from 576 million cubic metres per day in 2003 to 1,056 million cubic metres per day in 2012 or almost doubled during the decade (Figure 2). Of this amount, only a very small fraction of natural gas was supplied by the New Brunswick onshore deposits while the rest was supplied from outside the province by the Maritime and North-East Pipeline (M&NP). M&NP and its lateral pipelines is the only gas pipeline system in Atlantic Canada. It runs through the southern part of New Brunswick and therefore, the rest of the province is not covered by it.

Figure 2: Natural Gas Consumption in New Brunswick, data collected from Statistical Handbook for Canada's Upstream Petroleum Industry.



So, what can be done to balance the rapid growth of natural gas demand and to elevate spatial constrains of its distribution in the province? An increase in production of liquefied natural gas (LNG) can solve these problems, at least in the short run.

Therefore, major objective of this study is to address the above mentioned problems. This study uses system dynamics and quantitative methods to evaluate the economic impact of LNG utilization in the province of New Brunswick. LNG utilization affects regional economy in variety of ways. Therefore, in this study, microeconomic dynamics of the natural gas sector is coupled with macroeconomic regional dynamics to trace consequences of an increase in LNG utilization in the province of New Brunswick over time. First, initial economic impact of increasing natural gas supply due to LNG utilization is quantified, and then it is imposed on our dynamic model to trace its cumulative consequences over time.

This report is structured as follows. Chapter 1 discusses current role of LNG utilization and presents a review of the existing studies associated with economic impact analysis as well as its applications to LNG utilization. Chapter 2 describes our methodology designed to evaluate economic impact of increasing natural gas supply via LNG utilization in the province of New Brunswick. Chapter 3 describes our econometric model, data used as well as econometric tools applied. It also present the so-called counterfactual simulation of cumulative economic impact due to LNG utilization in the province of New Brunswick on the basis of the designed and estimated model. Chapter 4 is dedicated to the evaluation of regional economic impacts such as an increase in value added, tax revenue and job creation due to LNG utilization according to the results of counterfactual simulation presented in the previous chapter. In the end, we present our conclusion as well as major limitations of our study.

Chapter 1: Literature Review

1.1 LNG Utilization in the World, North America and Atlantic Canada

1.1.1 LNG Utilization in the World

The role and place of natural gas within global energy sector have been strengthened in past decades. Currently natural gas, the cleanest fossil fuel and the only one expected to grow, is being recognized as the key fuel for meeting the challenge of rising energy demands. Natural gas is odorless, colorless, non-toxic and non-corrosive and it can take on various forms and liquefied natural gas or LNG is of them. Currently LNG sector follows an upward trend as the main driver of globalization within the gas industry. In last 20 years, the LNG trade has evolved from an intra-regional status to achieve worldwide growth at a 10% rate a year and it is expected to continue to grow, albeit at a slower pace, driven by new technological developments and an extreme elasticity of the market. While in 2012, LNG trade slightly decreased following a downturn trend in European gas consumption. The shale gas revolution reduced the need for LNG imports in North America, while Asian market remained tight with LNG playing a key role as a substitute for nuclear power (The World LNG Report, 2013).

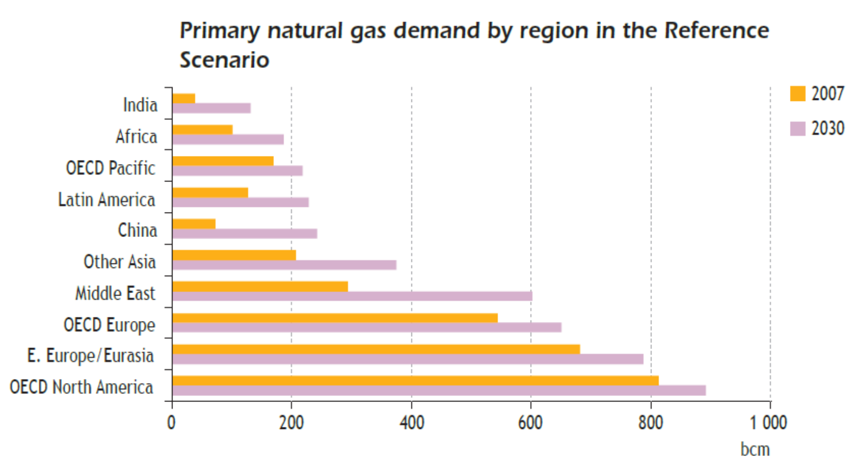
Thanks to advances in technology, more LNG is becoming available. An impressive 26 new projects were on their way at the end of 2012. New sources are expected to come in the medium term with the US Gulf Coast, the Canadian West Coast and East Africa expanding markets and diversification.

Global LNG demand should continue to grow in the short term, and the market will continue to be supply constrained. Traditional consumers will keep their place on the market and a large number of new players are expected to emerge. Such dynamics will accentuate the globalization of the LNG market and probably change the price environment for the benefit of a larger use of non-oil-linked pricing.

Asia will attract more and more diversified suppliers and will be the area of the largest supply growth. Strong demand from China and India, in addition to traditional importers such as Japan and Korea, will ensure that Asia Pacific market remains profitable for LNG suppliers. The US will, as it looks now, become a moderate-size exporter.

The World Energy Outlook estimates that the demand for natural gas grows on average by 1.5% per year. The biggest increase in absolute terms occurs in the Middle East. North America and Eastern Europe remain the leading gas consumers in 2030. These regions account for more than one-third of world consumption in 2030, compared with just under half today (figure 3).

Figure 3: Primary Natural Gas Demand by Region. Extracted from World Energy Outlook, 2009.



Moreover, gas production rises in all major regions except OECD Europe, where output from the North Sea is expected to decline steadily over time. In line with demand, the Middle East sees the biggest increase in production in volume terms over time. Output also increases markedly in Russia, the Caspian region and Africa. Unconventional sources, including tight gas, coalbed methane and shale gas, account for an increasing share of natural gas supply in North America and grow in absolute terms in some other regions.

1.1.2 LNG Utilization in North America

As we mentioned above, North America has always exhibited a strong appetite for natural gas, and the demand for this relatively clean burning natural resource will grow substantially in the years ahead. The United States and Canada have used natural gas for over one hundred years for a variety of industrial and commercial applications and to heat residential homes. Mexico and its less developed economy has always trailed its neighbors to the north in overall appetite for natural gas, but the country has long relied on natural gas as a feedstock for its petrochemical manufacturing facilities.

General energy picture for North America is summarized in Table 1. While the United States is both the largest producer and consumer of total energy on the continent, it consumes more than it produces. This negative net primary energy balance makes the United States the continent's only net importer of energy. Canada and Mexico are net exporters – with almost all of their energy trade directed toward U.S. demand.

Table 1: Primary Energy Supply and Demand in North America, 2001. Extracted from The Role of LNG in North American Natural Gas Supply and Demand, 2004.

Primary Energy Supply and Demand in North America, 2001
(quadrillion Btu, British thermal units)

	U.S.	Canada	Mexico
Total primary energy production	71.57	18.20	9.59
Of which natural gas (%)	20.23 (28.3%)	6.74 (37.0%)	1.38 (14.4%)
Total primary energy consumption	97.05	12.51	6.00
Of which natural gas (%)	22.87 (23.6%)	2.98 (23.8%)	1.46 (24.3%)
Total net primary energy balance (production-consumption)	-25.48	5.69	3.59
Net natural gas balance	-2.64	3.76	-0.08
Source: U.S. Energy Information Administration (U.S. EIA)			

1.1.3 LNG Utilization in Atlantic Canada

An increase in oil and natural gas prices in recent years has brought with it a focus on the high cost of energy, price volatility, and security of supply. Of particular concern is the mounting evidence that North America may not have enough conventional production to meet growing Canadian and US natural gas demand. High energy prices have spurred record domestic drilling activity, but productive capacity continues to decline. Natural gas consumers may face a supply-constrained market in the next several years until additional North American gas supplies can be brought to the market. There is an opportunity for liquefied natural gas (LNG) to fill the supply gap, and Atlantic Canada could be part of this opportunity.

In fact, Canada is the world’s 5th largest producer of natural gas with production of approximately 13.9 billion cubic feet per day. Western Canada is the major source of Canada’s natural gas production and currently accounts for approximately 98% of the country’s marketable production. Nova Scotia and New Brunswick provide most of the remaining natural gas production with minor amounts coming from Ontario, Northwest Territories, and Yukon. Canada's deliverability continues to exceed its own demand needs and the remaining production is exported to the U.S.

There are three Atlantic Canada projects, and they have received slightly different regulatory treatment, depending on the jurisdiction in which they are located and the process chosen to review the projects, and they will continue to do so. The region's pipeline system, Maritimes and Northeast Pipelines Limited Partnership (M&NP), is expected to be the main trunk line to US markets, but the regulatory treatment of the lateral links to Anadarko's Bear Island, NS, terminal or to the Irving Oil terminal at Canaport, NB, or the treatment of the interconnect to Keltic's project at Goldboro, NS, could have implications for tolls. The Irving and Anadarko projects have already successfully navigated some major environmental shoals, but more regulatory approvals will be required, including permits to connect to M&NP, licences from the NEB to import and export LNG, and permits from the NEB and FERC to expand the pipeline system to accommodate greater volumes of exports to the United States, to name just a few (Brian Lee Crowley, 2006).

Production of natural gas in Atlantic Canada mainly comes from the coast of Nova Scotia, particularly from the Sable offshore field, and onshore from the McCully natural gas field located near Sussex in New Brunswick. In 2012, this field produced 12 million cubic feet of natural gas per day. Onshore production from the McCully Field in New Brunswick was connected to the regional pipeline system at the end of June 2007. Maritime and North-East Pipeline (M&NP) with some lateral pipelines is only one natural gas pipeline in this region. M&NP goes through Nova Scotia and southern New Brunswick and to Boston in the US.

1.2 LNG Utilization and Economic Impact Analysis

This study aims to evaluate economic impact of LNG utilization in the province of New Brunswick on the basis of economic modeling. In general, economic impact analysis (EIA)

- Assesses impacts on sales, income, and jobs in a region,
- Is performed as with versus without analysis.

Major steps in EIA analysis are:

- Define the action(s)
- Identify affected segments of regional economy
- Define the study region
- Specify inputs and outputs
- Choose appropriate model
- Inspect, interpret and communicate results

In the next section, we are going to focus on segments of regional economy affected by LNG utilization.

1.2.1 Economic Effects of LNG Utilization

There exist several studies that examined economic impact of LNG utilization. According to them, potential benefits of increased production and utilization of LNG are: an increase in output, an increase in investment, an increase in employment, an increase in household income, an increase in productivity, and reduction in environmental costs.

Increase in Output: Philip Romero (2007) in his study estimated economic benefits of increased natural gas supplies due to LNG utilization. His “top down” macroeconomic method suggested that an increase in natural gas supply due to LNG utilization would reduce natural gas price by 10% which would increase regional gross domestic product by approximately $826 million.

Another economic impact study was done in 2008 regarding direct and indirect effects of proposed LNG Project on the economy of Papua New Guinea. Authors estimated that the LNG Project would provide a major boost to the country’s GDP and exports. According to their assessment, GDP would more than double, rising in real terms from $2.4 billion in 2006 to an average of $5.1 billion per year. Oil and gas exports would increase more than four-fold, with average annual product value from the LNG project of $3.2 billion, compared to total oil and gas exports of $0.7 billion in 2006.

In the province of New Brunswick, LNG can be used extensively in transportation, power generation, and other commercial and residential uses. Currently the northern part of New Brunswick is not covered by the local natural gas suppliers. If LNG can be quickly delivered to the rest of the province, it will stimulate the development of local industries and will eventually increase provincial gross regional output. Moreover, additional investments in LNG production and utilization will also affect New Brunswick’s economy directly and indirectly through increased demand for materials, construction, equipment and machinery, energy consumption, and so on.

Increase in Investment: Utilization of LNG requires large infrastructure investment both in areas where natural gas is extracted and liquefied as well as in places where it is transported and converted back into gas. According to one estimate, a re-gasification facility costs between $400 million and $600 million to construct (Smith et al. 2004). Another US study estimates that a national LNG project can deliver direct capital investment of US$10 billion in real terms over a 30-year life of the project (ACIL Tasman Pty Ltd, 2008).

Increase in Employment: Investment in LNG utilization will directly lead to increased demand for labor needed to produce or deliver LNG plus some related services. It may also indirectly create higher employment in the associated industries. LNG consumers such as commercial companies or public transport, increased output of natural gas may create an induced effect on the employment. Romero (2007) in his study discussed above estimated that after an increase in natural gas supply due to LNG utilization, regional employment would increase by up to 20,300 new jobs. Earlier discussed PNG LNG Economic Impact Study (2008) shows an increase in urban skilled and unskilled employment due to LNG utilization of 31%.

Increase in Household Income: Increased demand for labor due to LNG utilization will put upward pressure on wages which means higher household income. In addition, LNG is relatively cheaper compared to other fuels, so its utilization helps companies save on production costs and add output and therefore increase profits. As a result, it may increase income of self-employed contractors and business operators. It was found in Liquefied Natural Gas and the Pacific Northwest Project that if the production of LNG can be increased and natural gas prices can be reduced by 10%, households' income in Pacific Northwest would grow by $54 million to $214 million (Romero, 2007).

Reduction in Environmental Costs: LNG is odorless, colorless, non-toxic and non-corrosive product. It has the potential to reduce emissions of sulphur dioxide, nitrogen oxides, greenhouse gases and particulate matter in the area of its utilization. In fact, LNG is a clean and environmentally friendly fuel. It means that utilization of LNG will help the province to save on environmental costs as well.

1.3 Existing Models of Economic Impacts Analysis

According to our literature review, there are three basic methods widely used by researchers to evaluate economic impact of some activity. They are cost-benefit analysis (CBA), regional growth models (RGM) and regional economic models (REM). Each of these methods has its own advantages and weaknesses.

1.3.1 Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) places dollar values on the costs of a project and weighs those costs against the dollar value of the project's benefits to determine whether this project is worth undertaking. Therefore, the primary purpose of the CBA is aiding decision-maker in his/her comparison of the benefits and costs associated with a specific project, program or policy action.

CBA is easy to understand because after measuring the dollar values of the costs and benefits of a project, public can see directly whether the benefits outweigh the costs. CBA can be performed for various scenarios, locations and time horizons. Stephanie Riegg Cellini and James Edwin Kee (2010) state that CBA is the most useful when experts are analyzing a single program or policy to determine whether the program's total benefits to society exceed the total costs or when they are comparing alternative programs to see which one achieves the greatest benefits to the society.

However, CBA is not panacea that will provide decision makers with the answer to a policy problem. Although some view CBA as a superior technique, it is difficult to conduct and is time consuming. Moreover, it is often difficult to place dollar values on all or most costs and benefits. In fact, CBA is not optimization technique that allows us to choose the best possible solution but rather a test based on costs and benefits. In addition, it ignores the dynamic nature of the system under study, its cumulative and spill-over effects and uses very strong economic assumptions regarding consumer preference and the state of technology.

1.3.2 Regional Growth Models (RGM)

Regional Growth Models (RGM) can be used to capture long-run dynamics of an economic system under study and usually regard any new economic activity or action as a productivity shock to that system (Yuri Yevdokimov, 2014). They are based on neo-classical growth model as well as Kaldorian type models, real business cycle models, new economic geography models and some others. Regional growth models have three fundamental elements: labor supply, capital stock accumulation and technological progress. These models use highly aggregated data and ignore explicit and implicit costs and benefits associated with specific regional activities. Finally, these models lack microeconomic foundations. Due to those drawbacks they are not good tools to study economic impacts imposed on specific markets or economic sectors.

1.3.3 Regional Economic Models (REM)

Regional Economic Models (REM) are used to yield data-based predictions for a particular geographic or economic region. They are often used to do an economic impact analysis from a policy change or exogenous shocks in a counterfactual (alternative reality that did not happen) as compared to the actual data (what actually occurred). In general, this group of models include: Input/Output (I/O) Models and Computable General Equilibrium (CGE) models.

1.3.3.1 I/O Models

I/O models are essentially accounting tables which trace the linkages of inter-industry purchases and sales within a given county, region, state or country. The I/O model yields "multipliers" that are used to calculate the total direct, indirect and induced effect on employment, income and output generated per dollar of spending on various types of goods and services in the study area (Economic Development Research Group, 1997). Mostly these models are used to analyze the impact of capital investment. The I/O models have one significant limitation: they do not capture dynamic impacts over time. Moreover, these models are based on the key assumption that relative prices remain fixed, making them not suitable for the analysis when changes in relative prices become important. In addition, consumption side in these models is not well developed, and in general these models are useful for a short-term analysis of a small policy change.

1.3.3.2 Computable General Equilibrium (CGE) models

Computable General Equilibrium (CGE) models are based on a system of simultaneous equations that describe economic system under study at various levels. They use the power of today's computers to calculate numerically the effects of a particular change that is introduced into the model (Roberta Piermartini and Robert Teh, 2005). CGE models can be used to trace the propagation mechanism of various shocks throughout economic system over time and space. In general, they allow shocks to exogenous variables as well as endogenous variables such as output, employment, price and welfare (Brocker 2004, P269). When CGE model is set at a regional level, it is possible to identify the impact of future changes in socio-economic variables on regional development. Moreover, CGE models differ from I/O model in that they allow changes in relative prices. This group of models therefore has wider application possibilities and is particularly powerful with regard to fiscal policy changes, trade policy interventions and other policy changes (Western Cape Provincial Economic Review & Outlook, 2007). Furthermore, these models can also capture long-run dynamics in interactive interdependent way.

In our case, initial impact is imposed in energy sector of a regional economy in the form of an increase in energy output due to LNG utilization. However, since energy is used in production of almost all goods and services as well as a final consumption product, this initial impact will spill over the entire regional economy. Therefore, we need a model that reflects this fundamental feature of our approach: It has to have explicit energy sector with the rest of regional economy represented by aggregate macroeconomic dynamics. We call such a model hybrid since it takes its philosophy from RGM as well as REM which is explained in detail in the methodology section.

Chapter 2: Methodology

2.1 Major Economic Impacts of LNG Utilization in the Province

As mentioned before, in general economic impact analysis (EIA) consists of some important components. In Chapter 1, we briefly discussed segments of regional economy affected by LNG utilization. We continue this description with other components of the EIA in this section.

First, an increase in production of LNG in the province of New Brunswick can balance rapid growth of natural gas demand and elevate spatial constrains of its distribution in the province. LNG utilization will also improve provincial economy. At the present, distribution of natural gas in the province is mostly done by Enbridge Gas New Brunswick Inc. which buys natural gas from the owner of the M&NP and sells it to the customers via its system of local pipelines. Enbridge Gas New Brunswick serves over 7,500 institutional, commercial, industrial and residential customers. It has over 781 km of pipeline servicing 10 communities in southern New Brunswick including Dieppe, Dorchester, Fredericton, Moncton, Oromocto, Riverview, Sackville, Saint John, St. George and St. Stephen. There are two other suppliers of natural gas in the province – Irving Energy Services Limited and Park Fuels. All these companies are licensed by the New Brunswick Energy Utility Board (EUB).

However, in contrast with significant growth of natural gas supply in the US and western Canada, supply of natural gas in Atlantic Canada has been declining for several years. Meanwhile, based on National Energy Board projections, the demand for natural gas in Atlantic Canada will experience modest growth over the longer term. With regard to the province of New Brunswick, supply of natural gas is more or less sufficient only in the southern part of the province. However, the rest of the province is not covered by the local suppliers.

The existing and emerging natural gas infrastructure in Nova Scotia and New Brunswick has allowed natural gas to penetrate the residential, commercial, and industrial sectors. Consumption of natural gas in the province of New Brunswick increased from 41.4 million cubic feet per day in 2008 to 73.8 million cubic feet per day in 2012 or by 78%. As it can be easily calculated, the McCully Field can cover only 16% of the province's demand and therefore, the rest comes from the M&NP pipeline. In the future, we can expect an increase in consumption of natural gas in the province following the world trend. In addition, it is expected that the share of natural gas in total energy consumption is going to increase as well. Currently this share is 13% in the province of New Brunswick. In order to match growing demand for natural gas and to serve the province better in spatial sense, it is necessary to increase production of the liquefied natural gas (LNG).

LNG utilization is very important for the province of New Brunswick. First, natural gas is the cleanest-burning fossil fuel. It creates fewer greenhouse gas emissions than coal and oil, and when used to displace those fuels can result in up to 45% fewer emissions than coal and 30% fewer emissions than oil. Second, the safest way to transport natural gas to distant markets without pipelines is to cool it to the point where the gas becomes a liquid. LNG is 1/600th its original volume and can be stored in tanks and loaded on to specially designed LNG carriers and shipped safely and efficiently to distant customers. LNG is odourless, non-corrosive and non-toxic. If there were to be a spill, LNG does not mix with water or soil, and evaporates very quickly into the atmosphere. The LNG industry has an excellent global safety record. LNG has been shipped for more than 50 years and in that time there have been no major safety or environmental incidents. Finally, an increase in extraction of non-conventional natural gas such as shale gas, coalbed methane, tight gas calls for new ways of natural gas transportation. For example, there are deposits of coalbed methane in Pictou County, Nova Scotia located closely to the province of New Brunswick.

In addition, there is landfield gas in the province as well. For example, the Fredericton Region Solid Waste Commission earned a profit of $350,000 during its first year of producing electricity from landfield methane located near town of Lincoln. The landfill has produced more than 10 million kilowatt hours of power — enough to supply 1,000 homes. On the other hand, this gas can be used as a source for LNG.

So, it looks like there are four sources of natural gas in the province of New Brunswick that can be used to obtain LNG with further transportation to the consumers in the province not served by the existing system of pipelines: (i) the McCully Field, (ii) the Maritime and North-East Pipeline, (iii) coalbed methane in Pictou County, Nova Scotia, and (iv) landfield gas in Lincoln, Fredericton.

In addition to its environmental advantages, production and utilization of LNG in the province will bring tangible benefits in terms of an increase in supply of natural gas to the northern part of the province, decrease in costs of production of various goods and services, creation of new jobs, diversification of energy supply and some others. In order to evaluate these benefits over time, it is necessary to design a dynamic regional economic model, impose economic impacts from LNG utilization discussed in this section and trace consequences of these impacts over time.

2.2 Modeling Approach: Dynamic Demand-Supply Model

As stated before, major goal of this study is to evaluate aggregate economic impact of LNG utilization in the province of New Brunswick. At large, LNG utilization means an increase in natural gas supply which is first seen in the energy sector of provincial economy. However, LNG utilization affects provincial economy in variety of ways. Since energy is used in production of almost all goods and services as well as a final consumption product, this initial impact will spill over the entire provincial economy. Therefore, we need a model with explicit energy sector and the rest of provincial economy represented by regional macroeconomic dynamics.

In this study, we designed the so-called *hybrid model* which takes its philosophy from both RGM and REM described in Chapter 1. In our model, microeconomic dynamics of the natural gas sector is coupled with macroeconomic regional dynamics to trace consequences of an increase in LNG utilization in the province of New Brunswick over time. First, initial aggregate economic impact of an increase in natural gas supply due to LNG utilization is quantified, and then it is imposed on our dynamic model to trace its cumulative consequences over time.

Economic logic behind our model is as follows. First, our microeconomic dynamics is based on the principle of supply and demand equilibrium. We assume that at any point in time natural gas market in the province of New Brunswick is in equilibrium. Structural model includes dynamic equations of supply of and demand for natural gas and assumes that observed price-quantity pair in any period is obtained according to equilibrium condition. Second, all macroeconomic exogenous variables that affect our endogenous variables – the price of natural gas and its quantity – are assumed to grow over time at a constant rate. Finally, we regard an increase in the quantity of natural gas due to LNG utilization as a positive quantity shock to our model. It affects the equilibrium position and generates different time paths of endogenous variables. Therefore, we can generate two time paths: (i) without quantity shock, and (ii) with the quantity shock. The difference between the two will produce cumulative aggregate impact of LNG utilization.

2.3 Model Specification

2.3.1 Dynamic Demand-Supply Model

Supply and demand are fundamental concepts in economics. In general, market demand is the relationship between the quantity of goods or services purchased and the price charged for them, and market supply indicates the quantity of goods or services produced and the price of selling them. Therefore, there are two fundamental endogenous variables describing the market demand-supply system—market output and price. In this report, the demand-supply system was analyzed in this framework:

$$\begin{cases} Q^d = \mathrm{F}\ (\mathrm{P}, \mathrm{OILP}, CPI, \mathrm{GDP}, \mathrm{POP}, \mathrm{WAGER}, \varepsilon_1\ ) \\ Q^S = \mathrm{D}\ (\mathrm{P}, \mathrm{OILP}, \mathrm{CPI}, GDP, \mathrm{POP}, \mathrm{WAGER}, \varepsilon_2\ ) \end{cases}$$

Q^d: The quantity of natural gas demanded

Q^s: The quantity of natural gas supplied.

P : The market price of natural gas in the province of New Brunswick.

Where OILP, CPI, GDP, POP, and WAGER are pre-determined exogenous variables:

OILP: Oil Price.

CPI: Consumer Price Index.

GDP: Grows Domestic Product.

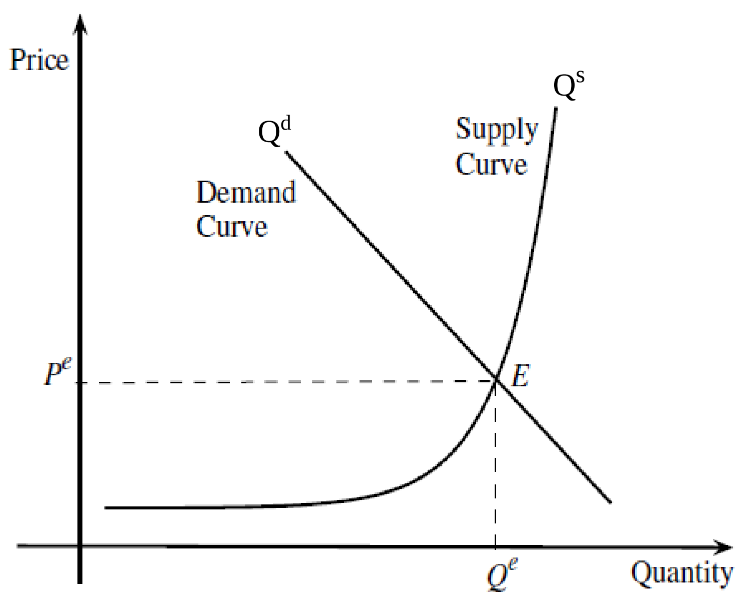
POP: Population.

WAGER: Wage Rate

ε_1 , ε_2 : Error terms.

In a competitive market, basic forces of supply and demand determine the price of a commodity and the quantity sold. The market for a particular commodity can be regarded as a collection of entities (individuals or companies) who are willing to buy or sell it. Under the assumption that the market is competitive, continuous interaction between suppliers and demanders establishes a unique price for the commodity (Mankiw, 1998).

Figure 5: Typical Supply and Demand Curves.



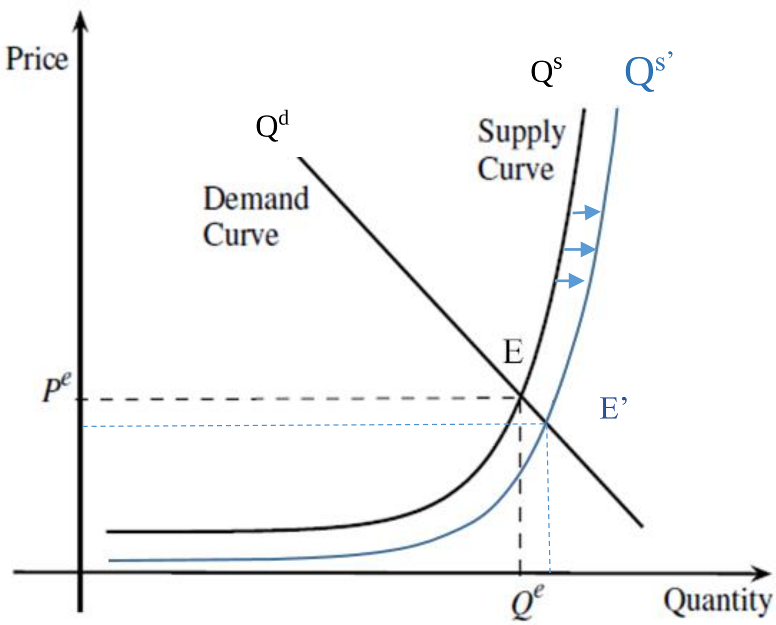
In figure 5, E = (P^e, Q^e) is the equilibrium point. According to specification of our demand/supply model, equilibrium natural gas price and quantity are given by the following system:

$$\begin{cases} Q^e = f_1(\mathrm{P}, \mathrm{OILP}, CPI, \mathrm{GDP}, \mathrm{POP}, \mathrm{WAGER}, \varepsilon_1) \\ P^e = f_2(\mathrm{P}, \mathrm{OILP}, \mathrm{CPI}, GDP, \mathrm{POP}, \mathrm{WAGER}, \varepsilon_2) \end{cases}$$

Market supply and demand are established by summing up individual supply and demand schedules. These schedules represent the quantity individuals are willing to trade at any unit price. The supply curve describes the relationship between the unit price and the total quantity offered by producers, and is upward-sloping. In the case of natural gas, this upward slope can be explained by the fact that increasing natural gas supply needs a higher production costs. The demand curve describes the relationship between the unit price and the total quantity desired by consumers. It is downward sloping since the higher the price, the less people will want to buy. The intersection of these two curves is the point where supply equals demand, and is called the market equilibrium. This is the point where the price balances supply and demand schedules. Under the assumption that the market operates efficiently, observed prices will adjust rapidly to this equilibrium point.

However, supply and demand curves vary over time due to various changing conditions causing equilibrium prices and quantities to fluctuate. In order to observe how LNG utilization affects New Brunswick economy, we introduce an increase in natural gas supply as a positive shock into the market, which moves the supply curve to the right. As a result, equilibrium point moves from E to E’ (see figure 6).

Figure 6: Dynamic Supply and Demand Curves



2.3.2 Exogenous Macroeconomic Dynamics

As already mentioned, our model is a hybrid model which takes its philosophy from both RGM and REM. RGM is used to capture long-run dynamics of a regional economic system with productivity shocks as driving force. In this study, an increase in the quantity of natural gas supplied due to LNG utilization is regarded as an example of productivity shocks which means that neoclassical growth model is behind this framework.

In general, theory of economic growth tries to explain what determines the long-run trend in an economic system. In another words, it tries to explain what determines shifts in the aggregate supply over time. Making an appropriate assumption about regional economic growth is very important because small differences in growth rates over long periods of time can make large differences in final outcomes.

In our model, we assume that each of the exogenous macroeconomic variables OILP, GDP, CPI, POP, WAGR grow exponentially at a constant rate. This assumption is taken from Solow growth model.

The Solow–Swan model is an exogenous growth model, an economic model of long-run economic growth set within the framework of neoclassical economics. It attempts to explain long-run economic growth by looking at capital accumulation, labor or population growth, and increases in productivity, commonly referred to as technological progress. At its core is a neoclassical aggregate production function, usually of a Cobb–Douglas type, which enables the model "to make contact with microeconomics".

In our case, LNG utilization increases the quantity of natural gas supply in the province of New Brunswick which affects energy market first and promotes economic growth in the province second.

Chapter 3: Econometric Estimation of the Model

3.1 Data Description

According to our analysis in Chapter 2, we identified the following variables of interest:

- Two major endogenous variables: quantity of natural gas (Q) and price of natural gas (P).
- Five exogenous variables: oil price (OILP), consumer price index (CPI), gross domestic product (GDP), population (POP), and the wage rate (WAGER).

In this study, all the data for these variables was taken from the Canadian Socio-Economic Information Management System (CANSIM). For our statistical analysis, we selected three Canadian provinces - New Brunswick, Quebec, and Ontario - and collected the associated data over 1997-2013 period. Three provinces were chosen to address the problem of a short time series data for New Brunswick. Data description table is presented in Appendix 4. Below we present brief description of the data set used.

Natural gas quantity (Q) – Natural gas use, final demand - Annual (1995-2013):

Data is provided by Statistics Canada, Table 128-0016 - Supply and demand of primary and secondary energy in terajoules, annual, CANSIM (database). It includes data of Canadian provincial supply of and demand for primary and secondary energy from 1995 to 2013. "Natural gas use, final demand" is summation of the usage of natural gas in mining and oil and gas extraction, manufacturing, forestry, construction, transportation, agriculture, residential, public administration and commercial and other institutional.

Natural gas price (P) - Sales unit price (cents per cubic metre)

Data is provided by Statistics Canada, table 129-0003 - Sales of natural gas, monthly, CANSIM (database) and was collected from the survey of Gas Utilities/Transportation and Distribution Systems (Monthly) - 2149. This monthly survey presents data about activities of Canadian natural gas distributors and transporters. Data collected covers a wide range of information such as direct sales, sales to residential, commercial, industrial customers and associated revenues, imports and exports. In order to keep uniform units with quantity, we converted natural gas price into dollars per terajoules. This data covers 1949-2015 period.

Oil price (OILP) – Average crude oil prices in Edmonton (Canadian dollars per barrel)

Data is extracted from the Transport Canada Addendum reports in Tables A2-57, EC63. The price of crude oil is regarded as a proxy for the unit cost of natural gas production. Therefore, it seems oil price should be positively related to the quantity of natural gas demand. The data covers 1991-2013 period.

Consumer price index (CPI)

Data is provided by Statistics Canada, Table 326-0021 - Consumer Price Index (CPI), 2011 basket, annual. CPI reflects general price index for all goods and services. Since we are interested in real price changes of natural gas this price index should be a part of our statistical model specification. The data covers 1995-2013 period.

Value Added by regional sectors, – Provincial GDP in annual terms × $1,000,000

Data is provided by Statistics Canada, Table 379-0030 - Gross domestic product (GDP) at basic prices, by North American Industry Classification System (NAICS), provinces and territories, annual (dollars), CANSIM (database). This indicator was used because GDP is the most important macroeconomic variable which affects and is affected by natural gas sector. In addition, it is the most important index to model future regional economic growth. At large, our goal is to estimate how LNG utilization affects value added in the province of New Brunswick. This data set was obtained from Gross Domestic Product by Industry - Provincial and Territorial (Annual) - 1303 and it covers 1997-2014 period.

Population (POP)

Data is provided by Statistics Canada. Table 051-0001 - Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons unless otherwise noted), CANSIM (database). Both demand and supply of natural gas are affected by the number of producers and consumers which in turn depends on the change in population. The data covers 1991-2014 period. For convenience of estimation, we converted the data into thousands of people.

Wage rate (WAGER) – Average hourly wage rate of all employees

Data is provided by Statistics Canada. Table 282-0070 - Labour force survey estimates (LFS), wages of employees by type of work, National Occupational Classification for Statistics (NOC-S), sex and age group, annual (current dollars), CANSIM (database). This data reflects average hourly wage rate of both full and part time employees who are fifteen years and older. The wage rate may affect the quantity of natural gas supplied since it is a part of production cost. On the other hand, the wage rate can affect income of consumers as well. The data set is obtained from Labour Force Survey - 3701 and it covers 1997-2014 period.

3.2 Econometric Model Specification: *VAR with Exogenous Regional Dynamics*

3.2.1 VAR Specification and Estimation

In our dynamic demand/supply model, we have two interdependent endogenous variables – the price of natural gas and the quantity of natural gas - plus a set of exogenous variables - determinants of demand and supply. In such a case, Vector Autoregression (VAR) can be used to estimate the model. However, since our time period is only 14 years, we added two other neighboring provinces to avoid this problem. Therefore, our statistical approach is based on panel VAR. In a theoretical sense, our VAR specification reflects reduced form of the dynamic demand/supply model.

Our panel VAR model can be presented as follows:

$$
\begin{aligned}
LnQ_{it} &= C(1)*LnQ_{it-1} + C(2)*LnP_{it-1} + C(3)*LnOILP_{it} + C(4)*LnCPI_{it} + C(5)*LnGDP_{it} \\
&\quad + C(6)*LnPOP_{it} + C(7)*LnWAGER_{it} + C(8)*DUMMY_{i} + C(9) \\
LnP_{it} &= C(10)*LnQ_{it-1} + C(11)*LnP_{it-1} + C(12)*LnOILP_{it} + C(13)*LnCPI_{it} \\
&\quad + C(14)*LnGDP_{it} + C(15)*LnPOP_{it} + C(16)*LnWAGER_{it} + C(17)*DUMMY_{i} + C(18)
\end{aligned}
\qquad (I)
$$

As stated above, besides endogenous variables Q and P, we have OILP, CPI, GDP, POP, WAGER as exogenous variables. Our data is panel data which includes three provinces: New Brunswick, Quebec, and Ontario. In order to incorporate them into the model, we added a dummy variable DUMMY assuming the value 1 for New Brunswick, 2 for Quebec and 3 for Ontario. In addition, we expressed all variables in natural logarithms to capture growth rates rather than levels of our economic variables.

There are several advantages of using VAR in this case:

(1) VAR allows lagged values of endogenous variables.

It means that VAR captures inter-temporal relationship. Although ideally VAR is able to include all necessary lags of endogenous variables, the VAR model described here has only one lag due to limited sample size.

In terms of our demand-supply system, it is assumed that the current natural gas quantity, Q_t is affected by both previous natural gas price level P_{t-1} and quantity Q_{t-1}; similarly, the current natural gas price P_t is also affected by both last period quantity Q_{t-1}

and price P_{t-1}. In addition, VAR specification includes some exogenous variables discussed before.

(2) VAR captures the interdependent relationship of the endogenous variables

VAR is specifically designed to describe the relationship among economic variables and study their evolution over time. While dealing with two interdependent variables Q and P, VAR assumes that the change in one economic variable will magnify the change in another economic variable in the future. In dynamic models, market output and price are determined inter-dependently over time.

(3) Error terms in the VAR are regarded as shocks/innovations

In general, error terms in any estimation are regarded as unobserved factors which could affect the model. In our econometric specification of VAR, error terms are treated as pure innovations or independent productivity shocks. Since in our model, we treat LNG utilization as positive aggregate quantitative shock, we can impose an increase in natural gas quantity due to LNG utilization via error term in the first equation of out VAR specification and then trace its consequences over time with the help of our VAR.

In our VAR model, we selected only one lag. Although more lagged periods may let the model perform better, it reduces the degree of freedom in the sample at the same time. As well, addition of more periods causes some loss in information about long-run trend which is the primary goal of our estimation. Since the available time series is quite short, the simplest one-lag VAR model was used in this study.

Our panel VAR was estimated in Eviews 8, and below results of this estimation are presented (see table 2).

Table 2: Estimation Results of VAR

System: Estimation Results of VAR
Estimation Method: Least Squares
Included observations: 48
Total system (balanced) observations 96

Dependent variable： LnQ

Variables	Coefficient		Std. Error	t-Statistic	Prob.
LnQ_{it-1}	C(1)	0.5831	0.1058	5.5121	0.0000
LnP_{it-1}	C(2)	-0.1216	0.0865	-1.4056	0.1638
$LnOILP_{it}$	C(3)	-0.0354	0.1285	-0.2752	0.7839
$LnCPI_{it}$	C(4)	-4.8225	1.7420	-2.7685	0.0070
$LnGDP_{it}$	C(5)	3.0609	0.8372	3.6561	0.0005
$LnPOP_{it}$	C(6)	-2.5870	0.7453	-3.4712	0.0008
$LnWAGER_{it}$	C(7)	0.6497	1.1176	0.5814	0.5627
$DUMMY_{i}$	C(8)	-0.2213	0.1309	-1.6912	0.0948
CONSTANT	C(9)	12.1565	4.9642	2.4488	0.0166

Dependent variable： LnP

Variables	Coefficient		Std. Error	t-Statistic	Prob.
LnQ_{it-1}	C(10)	0.1667	0.1297	1.2852	0.2025
LnP_{it-1}	C(11)	0.5244	0.1061	4.9409	0.0000
$LnOILP_{it}$	C(12)	0.6257	0.1576	3.9704	0.0002
$LnCPI_{it}$	C(13)	1.9131	2.1364	0.8955	0.3733
$LnGDP_{it}$	C(14)	-0.5882	1.0268	-0.5729	0.5684
$LnPOP_{it}$	C(15)	0.4874	0.9140	0.5332	0.5954
$LnWAGER_{it}$	C(16)	-2.5566	1.3707	-1.8652	0.0659
$DUMMY_{i}$	C(17)	0.1603	0.1605	0.9986	0.3211
CONSTANT	C(18)	1.0231	6.0883	0.1681	0.8670

Our estimated VAR equations therefore becomes:

$$LnQ_{it} = 0.58LnQ_{it-1} – 0.12LnP_{it-1} – 0.04LnOILP_{it} – 4.82LnCPI_{it} + 3.06LnGDP_{it} - 2.59LnPOP_{it} + 0.65LnWAGER_{it} – 0.22DUMMY_{i} + 12.16$$

$$LnP_{it} = 0.17LnQ_{it-1} + 0.52LnP_{it-1} + 0.63LnOILP_{it} + 1.19LnCPI_{it} - 0.59LnGDP_{it} + 0.49LnPOP_{it} – 2.56LnWAGER_{it} + 0.16DUMMY_{i} + 1.02 \quad \text{(II)}$$

Figure 7 and Figure 8 present comparison of the estimated quantity of natural gas and actual quantity of natural gas in the province of New Brunswick from 1997 to 2013 and comparison of estimated natural gas price and actual natural gas price from 1997 to 2013. As can be seen from the graphs, estimated time path is similar to the real one.

Figure7: Actual LnQ vs Estimated LnQ

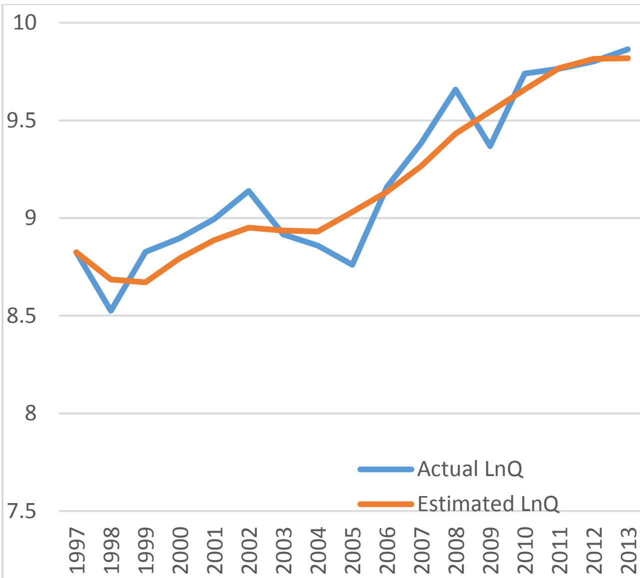
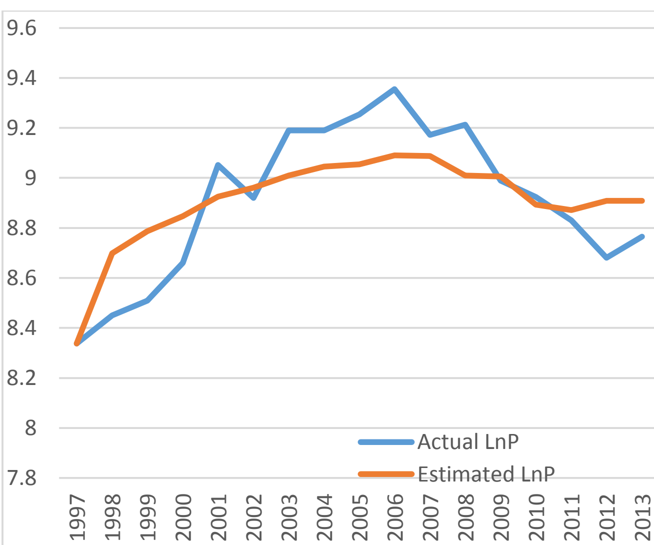


Figure8: Actual LnP vs Estimated LnP



3.2.2 Dynamics of Exogenous Variables

In order to see how LNG utilization affects the long-term economic development in the province of New Brunswick, it was also necessary to incorporate regional dynamics as well. In doing so, we have studied long-run dynamics of our regional economic variables such as GDP, CPI, oil price, population and wage. We did it with the help of autoregressive models. Econometric specification of these models is presented below:

$$LnOILP_t = \alpha_0 + \alpha_1 LnOILP_{t-1} + \alpha_2 T$$

$$LnCPI_t = \alpha_0 + \alpha_1 LnCPI_{t-1} + \alpha_2 T$$

$$LnGDP_t = \alpha_0 + \alpha_1 LnGDP_{t-1} + \alpha_2 T$$

$$LnPOP_t = \alpha_0 + \alpha_1 LnPOP_{t-1} + \alpha_2 T$$

$$LnWAGER_t = \alpha_0 + \alpha_1 LnWAGER_{t-1} + \alpha_2 T$$

According to the unit root test, some of our exogenous variables are non-stationary. The above specification of the models was chosen due to the fact that all these time series are I(1), and we assumed that they should be trend-stationary. Since our target area is the province of New Brunswick, here we only applied the data of New Brunswick. We used Eviews 8 to estimate parameters of the models in order to use them in our simulation exercise later. Results of this estimation are presented in Table 3.

Table 3: Estimated Results for Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNOILP				
C	-108.367	33.48042	-3.23672	0.0043
$LnOILP_{t-1}$	0.242774	0.220273	1.102151	0.2842
T	0.055548	0.017102	3.248025	0.0042
R-squared	0.890425	Adjusted R-squared		0.878891
F-statistic	77.19867	Prob(F-statistic)		0
Dependent Variable: LNCPI				
C	-6.3995	1.342558	-4.76665	0
$LnCPI_{t-1}$	0.798142	0.025986	30.71422	0
T	0.003669	0.000728	5.042281	0
R-squared	0.998106	Adjusted R-squared		0.997987
F-statistic	8430.102	Prob(F-statistic)		0
Dependent Variable: LNGDP				
C	-12.1266	4.366669	-2.77709	0.0095
$LnGDP_{t-1}$	0.801217	0.051998	15.40853	0
T	0.007065	0.002436	2.900613	0.007
R-squared	0.997568	Adjusted R-squared		0.9974
F-statistic	5947.92	Prob(F-statistic)		0
Dependent Variable: LNPOP				
C	0.45193	0.12579	3.592734	0.0009
$LnPOP_{t-1}$	0.932383	0.019343	48.20275	0
T	-1.6E-06	1.17E-06	-1.39375	0.1711
R-squared	0.99478	Adjusted R-squared		0.994519
F-statistic	3811.587	Prob(F-statistic)		0
Dependent Variable: LNWAGER				
C	-20.685	10.20158	-2.02763	0.0621
$LnWAGER_{t-1}$	0.661041	0.171704	3.849878	0.0018
T	0.010795	0.005322	2.028478	0.062
R-squared	0.995124	Adjusted R-squared		0.994427
F-statistic	1428.496	Prob(F-statistic)		0

3.3 Counterfactual Simulation

In this study, we applied the so-called counterfactual approach associated with the question “what if”. Therefore, after estimating our panel VAR, we generated two time paths for our endogenous variables: (i) one time path without positive quantity shock due to LNG utilization, and (ii) the other one with the shock. We assumed a 1% increase in quantity of natural gas due to LNG utilization for that purpose, and we generated time paths for price and quantity of natural gas according to the following specification:

$$\begin{aligned} \text{Shocked } LnQ_t &= C(1)*LnQ_{t-1} + C(2)*LnP_{t-1} + C(3)*LnOILP_t + C(4)*LnCPI_t + C(5)*LnGDP_t \\ &\quad + C(6)*LnPOP_t + C(7)*LnWAGER_t + C(8)*1 + C(9) + 0.01 \\ \text{Shorked } LnP_t &= C(10)*LnQ_{t-1} + C(11)*LnP_{t-1} + C(12)*LnOILP_t + C(13)*LnCPI_t \\ &\quad + C(14)*LnGDP_t + C(15)*LnPOP_t + C(16)*LnWAGER_t + C(17)*1 + C(18) + 0.01 \end{aligned} \qquad \text{(III)}$$

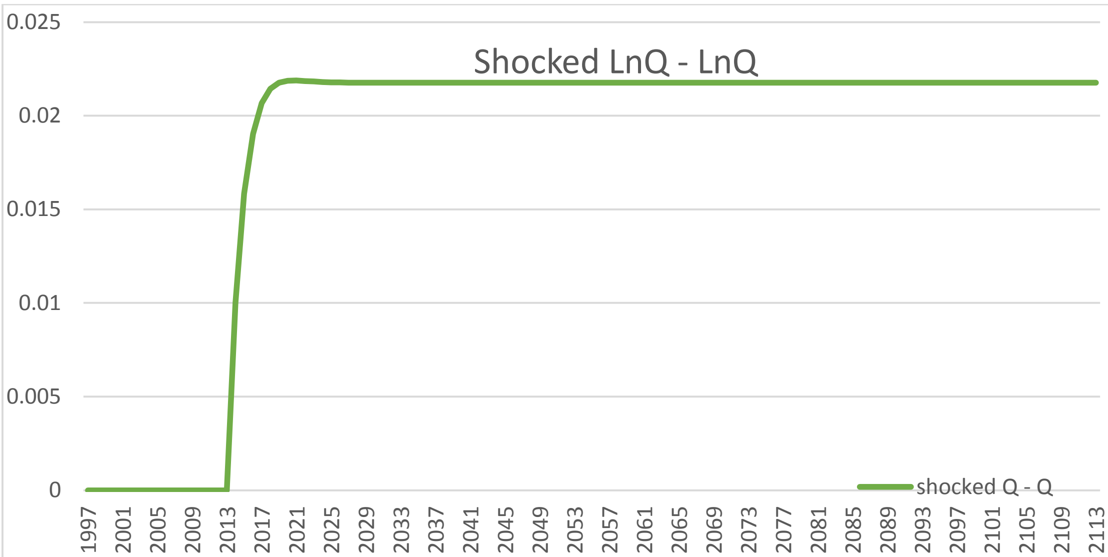
Coupled with dynamics of our exogenous variables we were able to simulate evolution of our demand/supply model over time due to following models:

$$\begin{aligned} LnQ_t &= 0.58LnQ_{t-1} – 0.12LnP_{t-1} – 0.04LnOILP_t – 4.82LnCPI_t + 3.06LnGDP_t \\ &\quad - 2.59LnPOP_t + 0.65LnWAGER_t – 0.22*1 + 12.16 \\ LnP_t &= 0.17LnQ_{t-1} + 0.52LnP_{t-1} + 0.63LnOILP_t + 1.19LnCPI_t \\ &\quad - 0.59LnGDP_t + 0.49LnPOP_t – 2.56LnWAGER_t + 0.16*1 + 1.02 \end{aligned} \qquad \text{(IV)}$$

$$\begin{aligned} \text{Shocked } LnQ_t &= 0.58LnQ_{t-1} – 0.12\text{Shocked } LnP_{t-1} – 0.04LnOILP_t – 4.82LnCPI_t + 3.06LnGDP_t \\ &\quad - 2.59LnPOP_t + 0.65LnWAGER_t – 0.22*1 + 12.16 + 0.01 \\ \text{Shocked } LnP_t &= 0.17\text{Shocked } LnQ_{t-1} + 0.52LnP_{t-1} + 0.63LnOILP_t + 1.19LnCPI_t \\ &\quad - 0.59LnGDP_t + 0.49LnPOP_t – 2.56LnWAGER_t + 0.16*1 + 1.02 \end{aligned} \qquad \text{(V)}$$

We evaluated the differences between LnQ and Shocked LnQ over time, and the result of the emerging time path is presented in figure 10. It means that our cumulative long-run increase in quantity of natural gas due to initial 1% increase because of LNG utilization is equal to 2.18%. In other words, the long-run multiplier associated with the output increase is equal to 2.18

Figure 10: Differences between LnQ and Shocked LnQ



While, we also trying to find what will happen if we assume the natural gas quantity in the province of New Brunswick increase in 2% or 3% and we found that the results are doubled or tripled than before.

Chapter 4: Economic Impact of LNG Utilization in New Brunswick

4.1 LNG Utilization and Value Added

The graph below shows simulated dynamics of quantity of natural gas and its price with a 1% quantity shock and without. Appendix 1 contains the detailed results of our estimation of these time paths.

Figure 11: Estimated Quantity with Shock and without Shock

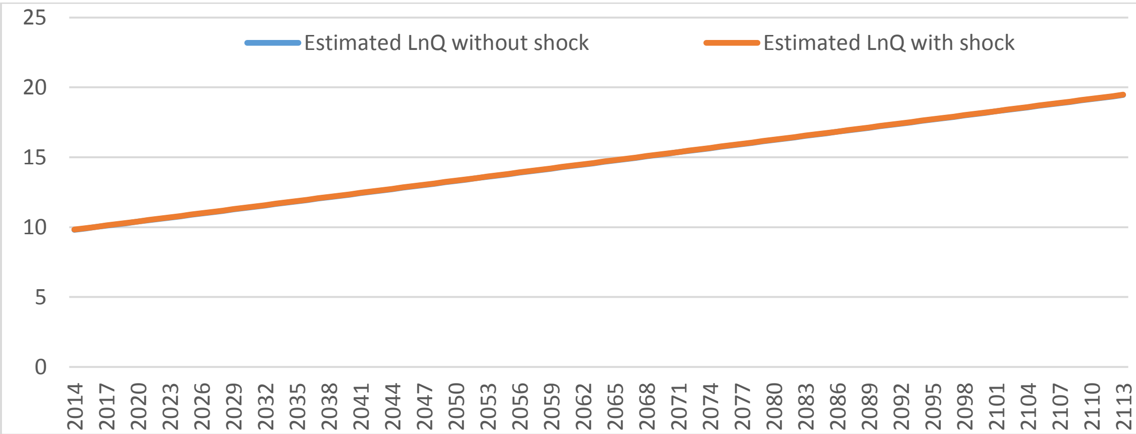
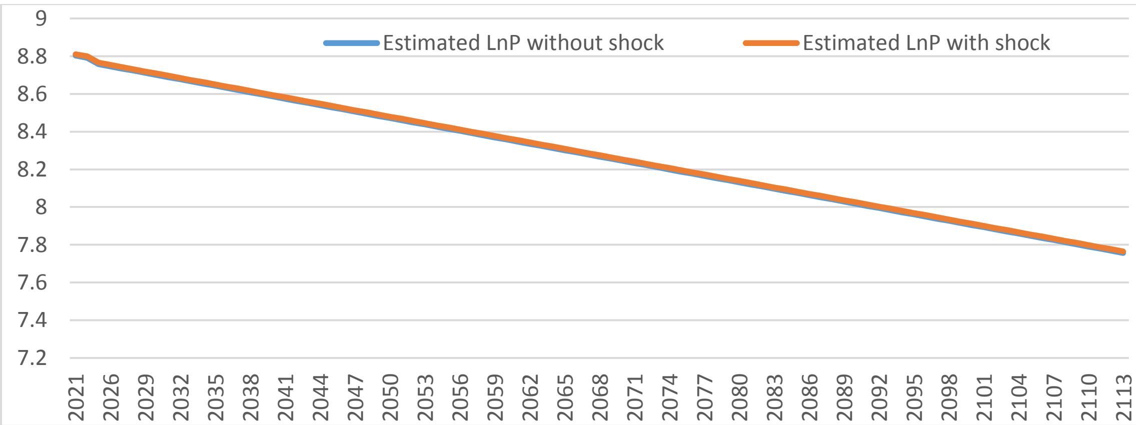


Figure 12: Estimated Price with Shock and without Shock



As can be seen from the graphs and the table, a 1% initial increase in LnQ results in cumulative increase of 2.18% in LnQ and 0.76% increase in LnP. If we assume a 1% increase in costs of natural gas production in the province of New Brunswick, then the increase in value added (ΔVA) due to LNG utilization can be defined as follow:

$$\Delta \mathrm{VA} = \Delta \mathrm{Q} + \Delta \mathrm{P} - \Delta \mathrm{C} = 2.18\% + 0.76\% - 1\% = 1.94\%$$

ΔQ: Percentage of changes in nature gas quantity.

ΔP: Percentage of changes in price of nature gas.

ΔC: Percentage of changes in cost of natural gas.

It means that a 1% initial increase in quantity of natural gas due to LNG utilization leads to a 1.94% cumulative long-run increase in value added. Value added (VA) itself can be defined as

$$\mathrm{VA} = \mathrm{Q} * (\mathrm{P} - \mathrm{C})$$

We calculated value added by natural gas due to an increase in LNG utilization for each year since initial increase and results are presented in Appendix 2.

Because new after-shock steady state is achieved in 15 years, we can select the year from 2014 to 2028 and use the following equation to calculate how much will the value added increase for each year if there is a 1% increase in LNG utilization.

$$VA\ increase = \frac{\sum_{i=1}^{15} \frac{VA_i}{(1+0.01)^i}}{15} \qquad \text{(VI)}$$

Using the data from 2014 to 2028 in Appendix 2, we achieved that value added of $88.63 million in 2013 and cumulative 1.94% increase in it according to initial 1% percentage increase in LNG utilization, eventually leads to $6.77 million per year increase in value added.

4.2 LNG Utilization and Labour Market

In order to see how LNG utilization affects labor market in the province of New Brunswick, we found the relationship between unemployment and provincial GDP. The data on labour force in New Brunswick was taken from *Statistics Canada. Table 282-0001 - Labour force survey estimates (LFS), by sex and detailed age group, unadjusted for seasonality, annual (persons unless otherwise noted).* It includes the amount of unemployed in the province of New Brunswick from 1981 to 2014 (Unit: unemployment ×1000). Since we already had the data on provincial GDP, we decided to co-integrate the two time series.

In general, classic regression model is based on stationary variables. For the non-stationary variables, using classic regression may lead to spurious regression. In our case, we used Eviews 8.0 to plot time paths for both unemployment and LnGDP (see Figure 11 and 12) in order to see whether or not the two are stationary.

Figure 13: Time Path for Unemployment

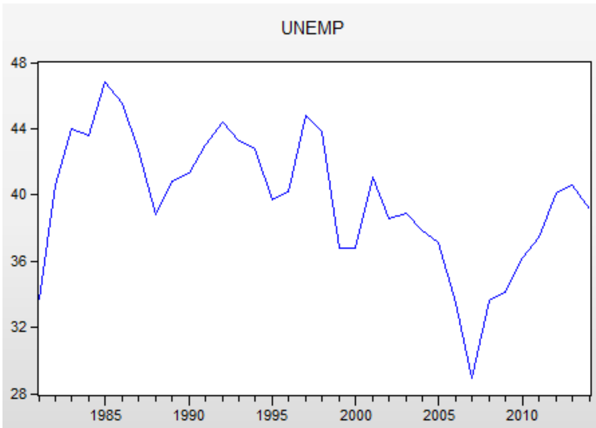
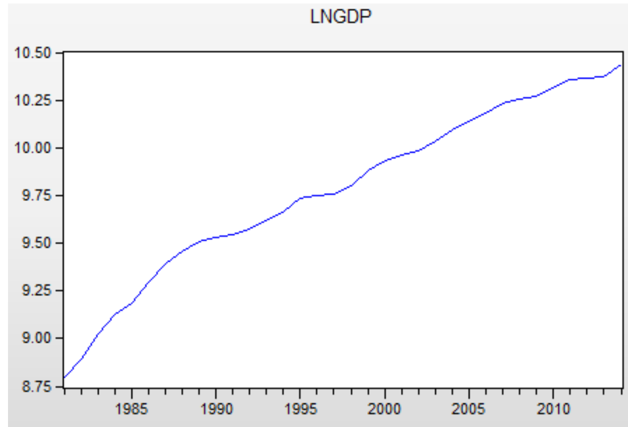


Figure 14: Time Path for LnGDP



According to figure 13 and figure 14 above and unit root test, both UNEMP and LnGDP are non-stationary. That is why we decided to do Jonhansen Cointegration Test in Eviews 8.0. As a result, we obtained the following relationship:

$$UNEMP=149.1127-10.68987\times LnGDP$$

The estimated parameter of LnGDP means that if provincial GDP increases by 1%, the predicted unemployment will decrease by 10,689 (10.68987× 1000) annually. Moreover, since value added by natural gas accounts for approximately 0.24% of the provincial GDP (Appendix 3), it means that a 1% increase in LNG utilization will lead to at least 25 (10,689×0.24%) new jobs created annually.

In addition, since the tax rate in the province of New Brunswick for small and medium size enterprises is equal to 15.5%, the value added of $88.63 million in 2013 and cumulative 1.94% increase in it according to initial 1% increase in LNG utilization, eventually leads to $6.77 million per year increase in value added on average and $1.049 ($6.77×15.5%) million in taxes for the government.

Conclusion

This study uses system dynamics, quantitative methods and simulation to evaluate potential economic impact of LNG utilization in the province of New Brunswick. Initial impact of quantity increase due to LNG utilization was imposed in energy sector of a regional economy. A hybrid dynamic model which takes its philosophy from RGM and REM was created to estimate consequences of this increase for the economy of New Brunswick. According to the estimated results and simulation exercise on the basis of our model, an addition of a 1% of LNG to the existing energy mix in the province of New Brunswick leads to (at least):

- annual increase in value added by $6.77 million;
- annual increase in taxes by $1.049 million;
- creation of 25 new jobs.

However, there are some limitation we need to mention. First of all, it is lack of reliable and consistent time series data, especially provincial data on natural gas price and quantity. The time period of our analysis is just 14 years which is not long enough for a rigorous time series analysis. This problem may lead to some bias in estimation. That is why we decided to use panel VAR instead of pure time series analysis. If there were enough time series data, it would be possible to include more lagged variables in VAR estimation. As well more predetermined (lagged) exogenous variables might capture system dynamics better.

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Appendix

Appendix 1: Comparison of Estimated LnQ, Shocked LnQ, LnP and Shocked LnP.

Year	Ln Q	Shocked LnQ - LnQ	Shocked LnQ	Ln P	Shocked LnP - LnP	Shocked LnP
1997	8.8242	0.0000	8.8242	8.3374	0.0000	8.3374
1998	8.7481	0.0000	8.7481	8.7010	0.0000	8.7010
1999	8.6948	0.0000	8.6948	8.8838	0.0000	8.8838
2000	8.6783	0.0000	8.6783	8.9680	0.0000	8.9680
2001	8.6960	0.0000	8.6960	9.0007	0.0000	9.0007
2002	8.7406	0.0000	8.7406	9.0081	0.0000	9.0081
2003	8.8042	0.0000	8.8042	9.0039	0.0000	9.0039
2004	8.8805	0.0000	8.8805	8.9948	0.0000	8.9948
2005	8.9649	0.0000	8.9649	8.9840	0.0000	8.9840
2006	9.0541	0.0000	9.0541	8.9729	0.0000	8.9729
2007	9.1463	0.0000	9.1463	8.9617	0.0000	8.9617
2008	9.2402	0.0000	9.2402	8.9506	0.0000	8.9506
2009	9.3351	0.0000	9.3351	8.9396	0.0000	8.9396
2010	9.4305	0.0000	9.4305	8.9286	0.0000	8.9286
2011	9.5263	0.0000	9.5263	8.9175	0.0000	8.9175
2012	9.6222	0.0000	9.6222	8.9064	0.0000	8.9064
2013	9.7183	0.0000	9.7183	8.8952	0.0000	8.8952
2014	9.8145	0.0100	9.8245	8.8839	0.0000	8.8839
2015	9.9108	0.0158	9.9266	8.8726	0.0017	8.8742
2016	10.0071	0.0190	10.0262	8.8612	0.0035	8.8647
2017	10.1035	0.0207	10.1242	8.8497	0.0050	8.8548
2018	10.2000	0.0214	10.2214	8.8383	0.0061	8.8444
2019	10.2965	0.0218	10.3183	8.8268	0.0068	8.8336
2020	10.3931	0.0219	10.4149	8.8153	0.0072	8.8225
2021	10.4897	0.0219	10.5116	8.8038	0.0074	8.8113
2022	10.5864	0.0219	10.6082	8.7924	0.0075	8.7999
2023	10.6831	0.0218	10.7049	8.7809	0.0076	8.7885
2024	10.7799	0.0218	10.8017	8.7694	0.0076	8.7770
2025	10.8767	0.0218	10.8985	8.7579	0.0076	8.7655
2026	10.9736	0.0218	10.9954	8.7464	0.0076	8.7540
2027	11.0705	0.0218	11.0923	8.7349	0.0076	8.7425
2028	11.1675	0.0218	11.1892	8.7234	0.0076	8.7311
2029	11.2645	0.0218	11.2862	8.7120	0.0076	8.7196

2030	11.3615	0.0218	11.3833	8.7005	0.0076	8.7081
2031	11.4586	0.0218	11.4803	8.6891	0.0076	8.6967
2032	11.5557	0.0218	11.5774	8.6776	0.0076	8.6852
2033	11.6528	0.0218	11.6746	8.6662	0.0076	8.6738
2034	11.7499	0.0218	11.7717	8.6547	0.0076	8.6624
2035	11.8471	0.0218	11.8689	8.6433	0.0076	8.6509
2036	11.9443	0.0218	11.9661	8.6319	0.0076	8.6395
2037	12.0416	0.0218	12.0633	8.6204	0.0076	8.6281
2038	12.1388	0.0218	12.1606	8.6090	0.0076	8.6167
2039	12.2361	0.0218	12.2579	8.5976	0.0076	8.6052
2040	12.3334	0.0218	12.3552	8.5862	0.0076	8.5938
2041	12.4307	0.0218	12.4525	8.5748	0.0076	8.5824
2042	12.5280	0.0218	12.5498	8.5634	0.0076	8.5710
2043	12.6254	0.0218	12.6471	8.5520	0.0076	8.5596
2044	12.7227	0.0218	12.7445	8.5406	0.0076	8.5482
2045	12.8201	0.0218	12.8419	8.5292	0.0076	8.5369
2046	12.9175	0.0218	12.9393	8.5178	0.0076	8.5255
2047	13.0149	0.0218	13.0367	8.5065	0.0076	8.5141
2048	13.1123	0.0218	13.1341	8.4951	0.0076	8.5027
2049	13.2097	0.0218	13.2315	8.4837	0.0076	8.4913
2050	13.3071	0.0218	13.3289	8.4723	0.0076	8.4799
2051	13.4046	0.0218	13.4263	8.4609	0.0076	8.4686
2052	13.5020	0.0218	13.5238	8.4496	0.0076	8.4572
2053	13.5995	0.0218	13.6212	8.4382	0.0076	8.4458
2054	13.6969	0.0218	13.7187	8.4268	0.0076	8.4345
2055	13.7944	0.0218	13.8162	8.4155	0.0076	8.4231
2056	13.8919	0.0218	13.9137	8.4041	0.0076	8.4117
2057	13.9894	0.0218	14.0111	8.3927	0.0076	8.4004
2058	14.0869	0.0218	14.1086	8.3814	0.0076	8.3890
2059	14.1844	0.0218	14.2061	8.3700	0.0076	8.3776
2060	14.2818	0.0218	14.3036	8.3586	0.0076	8.3663
2061	14.3794	0.0218	14.4011	8.3473	0.0076	8.3549
2062	14.4769	0.0218	14.4986	8.3359	0.0076	8.3435
2063	14.5744	0.0218	14.5961	8.3246	0.0076	8.3322
2064	14.6719	0.0218	14.6936	8.3132	0.0076	8.3208
2065	14.7694	0.0218	14.7912	8.3018	0.0076	8.3095
2066	14.8669	0.0218	14.8887	8.2905	0.0076	8.2981
2067	14.9644	0.0218	14.9862	8.2791	0.0076	8.2868
2068	15.0620	0.0218	15.0837	8.2678	0.0076	8.2754
2069	15.1595	0.0218	15.1813	8.2564	0.0076	8.2640
2070	15.2570	0.0218	15.2788	8.2451	0.0076	8.2527
2071	15.3546	0.0218	15.3763	8.2337	0.0076	8.2413
2072	15.4521	0.0218	15.4739	8.2224	0.0076	8.2300

2073	15.5496	0.0218	15.5714	8.2110	0.0076	8.2186
2074	15.6472	0.0218	15.6689	8.1997	0.0076	8.2073
2075	15.7447	0.0218	15.7665	8.1883	0.0076	8.1959
2076	15.8422	0.0218	15.8640	8.1770	0.0076	8.1846
2077	15.9398	0.0218	15.9616	8.1656	0.0076	8.1732
2078	16.0373	0.0218	16.0591	8.1542	0.0076	8.1619
2079	16.1349	0.0218	16.1566	8.1429	0.0076	8.1505
2080	16.2324	0.0218	16.2542	8.1315	0.0076	8.1392
2081	16.3300	0.0218	16.3517	8.1202	0.0076	8.1278
2082	16.4275	0.0218	16.4493	8.1089	0.0076	8.1165
2083	16.5251	0.0218	16.5468	8.0975	0.0076	8.1051
2084	16.6226	0.0218	16.6444	8.0862	0.0076	8.0938
2085	16.7202	0.0218	16.7419	8.0748	0.0076	8.0824
2086	16.8177	0.0218	16.8395	8.0635	0.0076	8.0711
2087	16.9153	0.0218	16.9371	8.0521	0.0076	8.0597
2088	17.0128	0.0218	17.0346	8.0408	0.0076	8.0484
2089	17.1104	0.0218	17.1322	8.0294	0.0076	8.0370
2090	17.2080	0.0218	17.2297	8.0181	0.0076	8.0257
2091	17.3055	0.0218	17.3273	8.0067	0.0076	8.0143
2092	17.4031	0.0218	17.4248	7.9954	0.0076	8.0030
2093	17.5006	0.0218	17.5224	7.9840	0.0076	7.9916
2094	17.5982	0.0218	17.6199	7.9727	0.0076	7.9803
2095	17.6957	0.0218	17.7175	7.9613	0.0076	7.9690
2096	17.7933	0.0218	17.8151	7.9500	0.0076	7.9576
2097	17.8909	0.0218	17.9126	7.9386	0.0076	7.9463
2098	17.9884	0.0218	18.0102	7.9273	0.0076	7.9349
2099	18.0860	0.0218	18.1077	7.9159	0.0076	7.9236
2100	18.1835	0.0218	18.2053	7.9046	0.0076	7.9122
2101	18.2811	0.0218	18.3029	7.8932	0.0076	7.9009
2102	18.3787	0.0218	18.4004	7.8819	0.0076	7.8895
2103	18.4762	0.0218	18.4980	7.8706	0.0076	7.8782
2104	18.5738	0.0218	18.5955	7.8592	0.0076	7.8668
2105	18.6713	0.0218	18.6931	7.8479	0.0076	7.8555
2106	18.7689	0.0218	18.7907	7.8365	0.0076	7.8441
2107	18.8665	0.0218	18.8882	7.8252	0.0076	7.8328
2108	18.9640	0.0218	18.9858	7.8138	0.0076	7.8214
2109	19.0616	0.0218	19.0834	7.8025	0.0076	7.8101
2110	19.1592	0.0218	19.1809	7.7911	0.0076	7.7988
2111	19.2567	0.0218	19.2785	7.7798	0.0076	7.7874
2112	19.3543	0.0218	19.3760	7.7684	0.0076	7.7761
2113	19.4518	0.0218	19.4736	7.7571	0.0076	7.7647

Appendix 2: Value Added for Natural Gas in NB

Year	Value added (dollars*1000,000)	Year	Value added (dollars*1000,000)	Year	Value added (dollars*1000,000)
1997	16.15681485	2036	137.8828911	2075	291.7097344
1998	14.502692	2037	140.5578192	2076	297.3689032
1999	21.5489405	2038	143.2846409	2077	303.1378599
2000	28.98542721	2039	146.0643629	2078	309.0187344
2001	54.31022908	2040	148.8980115	2079	315.0136979
2002	52.86082991	2041	151.786633	2080	321.1249636
2003	59.59742804	2042	154.7312936	2081	327.3547879
2004	56.29217352	2043	157.7330807	2082	333.7054708
2005	55.17417477	2044	160.7931025	2083	340.1793569
2006	92.73193053	2045	163.9124887	2084	346.7788365
2007	93.01444953	2046	167.092391	2085	353.5063459
2008	128.7604536	2047	170.3339833	2086	360.364369
2009	72.75994486	2048	173.6384626	2087	367.3554378
2010	97.02513821	2049	177.0070488	2088	374.4821332
2011	87.67119553	2050	180.4409855	2089	381.7470866
2012	73.83884299	2051	183.9415407	2090	389.1529801
2013	88.63064465	2052	187.5100066	2091	396.7025479
2014	90.35007916	2053	191.1477007	2092	404.3985774
2015	92.10287069	2054	194.8559661	2093	412.2439098
2016	93.88966639	2055	198.6361718	2094	420.2414416
2017	95.71112591	2056	202.4897135	2095	428.3941256
2018	97.56792176	2057	206.418014	2096	436.7049716
2019	99.46073944	2058	210.4225235	2097	445.1770481
2020	101.3902778	2059	214.5047204	2098	453.8134828
2021	103.3572492	2060	218.666112	2099	462.6174644
2022	105.3623798	2061	222.9082346	2100	471.5922432
2023	107.40641	2062	227.2326543	2101	480.7411327
2024	109.4900943	2063	231.6409678	2102	490.0675107
2025	111.6142022	2064	236.1348026	2103	499.5748204
2026	113.7795177	2065	240.7158178	2104	509.2665719
2027	115.9868403	2066	245.3857046	2105	519.1463434
2028	118.236985	2067	250.1461873	2106	529.2177824
2029	120.5307825	2068	254.9990233	2107	539.4846074
2030	122.8690797	2069	259.9460044	2108	549.9506088
2031	125.2527399	2070	264.9889569	2109	560.6196506
2032	127.682643	2071	270.1297426	2110	571.4956718
2033	130.1596863	2072	275.3702596	2111	582.5826879
2034	132.6847842	2073	280.7124427	2112	593.884792
2035	135.258869	2074	286.1582641	2113	605.406157

Appendix 3: Average of Value Added Accounts for GDP in NB

	Year	Value Added (VA)	GDP	VA/GDP
1	1997	16.1568	17288	0.0009
2	1998	14.5027	18046	0.0008
3	1999	21.5489	19525	0.0011
4	2000	28.9854	20556	0.0014
5	2001	54.3102	21141	0.0026
6	2002	52.8608	21653	0.0024
7	2003	59.5974	22746	0.0026
8	2004	56.2922	24116	0.0023
9	2005	55.1742	25272	0.0022
10	2006	92.7319	26378	0.0035
11	2007	93.0144	27869	0.0033
12	2008	128.7605	28422	0.0045
13	2009	72.7599	28825	0.0025
14	2010	97.0251	30082	0.0032
15	2011	87.6712	31409	0.0028
16	2012	73.8388	31751	0.0023
17	2013	88.6306	31900	0.0028
Sum				0.0414
Average (Sum/17)				0.0024

Appendix 4: Data Description

Descriptive statistics

	LnQ	LnP	LnOILP	LnCPI	LnGDP	Lnpop/1000	lnwage
count	51.00	51.00	51.00	51.00	51.00	51.00	51.00
mean	11.73	8.99	3.94	4.66	11.94	8.33	2.90
sample variance	3.63	0.09	0.18	0.01	1.82	1.53	0.03
sample standard deviation	1.91	0.31	0.43	0.10	1.35	1.24	0.17
minimum	8.52	8.34	3.01	4.50	9.76	6.61	2.56
maximum	13.77	9.50	4.46	4.81	13.45	9.51	3.20
range	5.24	1.16	1.45	0.31	3.69	2.90	0.64

Curriculum Vitae

Candidate's full name: Xiaochen Zhou

Universities attended:

University of Prince Edward Island, Charlottetown, PEI, Canada, 2010-2013, B.A. in Business Administration

Sichuan University, Chengdu, Sichuan, China, 2008-2010, B.A. in Business Administration with major in Human Resources