Cost Benefit Analysis of the Keystone XL Pipeline

by

Daniel J. Carr

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Abstract

Advisor: Harold Fried

The Keystone XL pipeline is one of the most controversial topics in North America over the last five years. The debate is based on the trade-off between Canadian oil sands as a usable energy resource and the environmental effects associated with the extraction and refining of the oil. The green house gasses emitted from the extraction and refining of oil sands produces several environmental concerns that make the proposed pipeline controversial. On the other hand, Canadian oil companies see a significant benefit from the ability of Canadian oil reaching international markets. TransCanada, a 79.99 percent owner of the pipeline, conducted an evaluation of the pipeline; however, their valuations have been questioned due to their bias. This paper provides an objective analysis of the pipeline, from the perspective of Canada. Through conducting a Cost-Benefit Analysis, it finds that the pipeline provides a net-benefit of $118 billion dollars to Canada and its citizens.

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Chapter 1: Introduction

Nikola Tesla once said, "If you want to find the secrets of the universe, think in terms of energy, frequency, and vibration." I believe Tesla understood that for society to progress forward, it has to understand how it is going to find the energy sources to sustain itself. Society has to comprehend that it needs to find new viable sources of energy to continue to grow. The Canadian oil sands have the ability to fuel Canada forward.

The Canadian oil sands are a very controversial energy source. Some argue they are a means to supply North America's future energy needs, while others argue they are just darkened sand. There is a vast quantity of the oil situated in Western Canada; estimates are that there are roughly 175 billion barrels of oil. The question is, how does Canada export this oil?

The Keystone XL pipeline is a 2,700-kilometer pipeline that stretches from central Alberta, Canada to the American Gulf Coast. It creates the ability for Canadian oil to reach the United States as well as other international markets with ease. There are numerous benefits that this pipeline creates for Canada. It gives Canadian oil companies additional foreign customers to sell too and brings billions of dollars to Canada. Also, the owner of the pipeline, TransCanada, profits substantially from American producers paying transportation. However, there are significant risks and costs associated with the pipeline. Oil sands extraction and refining emit significant amounts of green house gasses into the atmosphere. Environmentalists use these emissions as an argument against the pipeline. Spills are also a focal point of arguments against pipelines in general. For the Keystone XL, there is the possibility of severe environmental damage if a spill occurs near the Sandhill region of Nebraska. Multi-billion dollar industries rely on the ground water from this region to survive and a contamination in this region would be catastrophic.

This paper compares the costs and benefits of the Keystone XL pipeline from the perspective of Canada. It remains unbiased in its valuations and provide an objective analysis of the pipeline. TransCanada has conducted its own evaluation of the pipeline; however, environmentalists and those who are opposed to the pipeline debate their valuations of costs and benefits.

The remainder of this thesis is organized as follows. Chapter 2 discusses the issues regarding the Canadian oil sands, the Keystone XL pipeline, and Northern Gateway pipeline. Both of these pipelines are proposed to ship oil out of Western Canada to international markets. Chapter 3 is a primer on Cost-Benefit Analysis (CBA). This chapter explains the concepts in CBA and discusses the critical assumptions. Chapter 4 is a CBA of the Keystone XL pipeline. Chapter 5 concludes the thesis.

Chapter 2 examines the Alberta oil sands and two pipelines out of Alberta: the Keystone XL and the Northern Gateway. It begins by examining how the Alberta oil sands grew into the primary industry in Alberta. It then explains the difference between crude oil and tar sands oil. The primary difference is that crude oil is extracted as just that; however, tar sands are harder to extract and require some refining to turn into crude oil. The chapter then shifts to a discussion of pipelines in general, then to the two specific pipelines. Lastly, the chapter discusses the environmental concerns with the oil sands in general, then the two specific pipelines.

Chapter 3 is a primer on CBA. It begins explaining how CBA came to be a practice and progresses to explain why perspective is important. In CBA, perspective has to be declared in the beginning because costs and benefits need to evaluate based on whom the analysis is representing. Next, the four stages of CBA are identified and discussed. Finally, controversies of CBA are acknowledged. If three analyses are conducted on the same project, it is very common to have three different results. CBA involves valuing costs and benefits to the socially optimum price. When different people conduct these estimations, there are going to be different results.

Chapter 4 is a CBA of the Keystone XL pipeline from the Canadian perspective. There are three models. Model 1 is a basic model comparing the sunk cost to build the pipeline to the benefits that Canadian oil companies obtain and the benefit to TransCanada. Model 2 then adds the cost of carbon pollution to capture the environmental effects of extracting and refining the oil sands to be shipped through the pipeline. Finally, Model 3 inserts the risk of a spill into the calculations. Chapter 5 concludes the thesis.

Chapter 2: The Issues

I. Introduction

Some people's trash is other people's treasure. Energy investors, and most economists view the oil sand deposits in Western Canada as a gold mine; they see the second largest crude oil reserve in the world. On the other hand, environmentalists simply see dirty sand. They believe that the extra costs and environmental effects of extracting the sand and then refining it to heavy crude oil are too high. The question is what does society want for an energy policy? Do they want energy? Do they want environmental safety? This difference in points of view is what makes the Canadian oil sands one of the hottest topics in modern economics.

In 2011, the Energy Information Administration (EIA) reported that Canada has the third largest proven crude oil reserves in the world, only behind Saudi Arabia and Venezuela. The Canadian Association of Petroleum Producers (CAPP) estimates that there are 175 billion barrels of oil in Canada. They also estimate that the oil industry is currently an $80.7 billion per year business that employs 230 thousand people. In 2012, 3.23 million barrels per day were produced in Canada, which is an increase from the 3.02 million barrels per day that were produced in 2011. There is no doubt that the industry is growing. However, TD, a large North American bank, predicts that the oil business cannot continue to grow without additional pipelines being built out of Western Canada and specifically Alberta where the majority of the oil is situated.

In the last decade, two proposals have been given to transport oil from Alberta to different coastlines of North America. TransCanada proposed the

Keystone XL pipeline, and Enbridge plans the Northern Gateway pipeline. Both proposals would be efficient ways to transport Canadian crude oil out of Western Canada and to the rest of the world. However, environmentalists strongly resist both pipelines. The Keystone XL pipeline travels south from Alberta down to the Gulf of Mexico, giving the USA and many other countries easy access to Canadian oil. The Northern Gateway pipeline travels west from Alberta to the Pacific coast of Canada. The Northern Gateway pipeline opens up Canadian oil sands to markets all along the Pacific Rim.

The remainder of this chapter is organized as follows. Section II is a history of the Alberta Sands and describes how the oil sands became the driving force of the Albertan economy. Section III discusses the difference between the Canadian oil sands and conventional crude oil. It reveals that oil sands take more refining to turn into a usable form of energy than conventional crude oil. Section IV discusses pipelines in general. Section V examines the two proposed pipelines, providing details about the Keystone XL and Northern Gateway pipelines. Section IIX talks discusses environmental issues and obstacles the pipelines face. Finally, section IX concludes the chapter.

II. History of the Alberta Oil Sands

The oil industry in Alberta did not become profitable until roughly 1997. Before then, the cost of transforming oil sands into crude oil was too high for companies to make a profit. In 1997 the provincial government implemented a royalty and tax regime that changed everything.

The Alberta government realized that the large reserves in their province could be a driving force for the economy. In 1997, they implemented a single approach royalty and tax regime to stimulate investment into the Alberta oilfield. This was very different from the individual negotiations they did with each company in the decades before. They changed the tax laws so that all income could be claimed against Canadian Income Tax. Prior to this reform, companies could only claim income from strip mining (which involves excavating the oil sands within 75 meters of the earth's surface), and excluded in situ (which is the process of drilling below 75 meters, and extracting the deeper oil sands). This provided incentive for companies to develop new and more efficient ways to reach the vast reserves below 75 meters. They changed the royalty program to a "revenue minus cost" approach. In this system, companies paid a one percent royalty until their revenues exceeded their costs, and they began making a profit. At that point, they began paying 25 percent in royalties.

During the early to mid 2000's oil prices began to rise dramatically. From 1991 to 2006, oil prices rose from $25 to $76 per barrel. This price increase, along with the 1997 policy reforms, stimulated in excess of $70 billion in investments and operating expenditures reached $40 billion.[1]

In 2007 the Alberta oilfield was booming and the Alberta government decided they wanted a bigger piece of the pie. They changed the base royalty to vary from one to nine percent and also changed the "revenue minus cost" royalty to where it could range from 25% to 40% depending on the current price of oil. If oil

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[1] All figures are in 2007 dollars
[2] Prices are based upon the WTI price
[3] The Alaska pipeline is above ground because it would melt the permafrost.

prices were at or below $55 per barrel, then the royalties were at their minimum, but if they were at or above $120 per barrel, then they were at their maximum.[2] The government did not change the tax law because they still wanted companies to invest in technology that could make mining and refining of oil sands more efficient.

Heading into the future, there are two main drivers of optimism in the Alberta oil industry: the large size of the resource base, and the future of oil prices. The 175 billion barrels of crude oil in Alberta give comfort to Albertans in the industry. They feel safe knowing that because of the large resource base, there will be oil to extract for a long time. The second driver of optimism is the fact that high oil prices since the turn of the decade seem to be holding. These high prices have shown to lead to investment into the province.

III. Difference Between Oil Sands and Crude Oil

Canada has 175 billion barrels of oil and, of that, 169 billion barrels are oil sands. The difference between crude oil and oil sands has to be understood. Crude oil is generally found in pools in the ground and does not need significant refining, whereas oil sands are essentially large blocks of clay, sand, water, and hydrocarbons. Once these oil sands are excavated from the ground, refineries extract the bitumen from them. Bitumen, in simplest terms, is the oil sand form of crude oil. A full barrel of bitumen can be refined into roughly 0.8 of a barrel of crude oil. This difference between crude oil and oil sands is why oil sands are often referred to as "Non-Conventional" oil.

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[2] Prices are based upon the WTI price

The extraction of bitumen from the earth is quite different than that of crude oil. Crude oil is pumped out of the earth from pools, whereas bitumen is extracted either through strip mining or in situ. Strip mining is, as it sounds, the excavation of the earth—sand, water, clay, hydrocarbons and other materials—from within 75 meters of the earth surface. In situ is the drilling for oil sands below 75 meters. In situ is essentially the pumping of heat or steam down a well to force the oil sands to the surface. This process uses a lot of water and is one reason why oil sands are considered “Non-Conventional.”

The largest debate about the use of bitumen as crude is the amount of green house gasses (GHG) emitted during the refining of bitumen. To turn bitumen into a usable energy source, it takes plenty of refining compared to crude oil. This increased refining leads to a larger amount of carbon emitted into the atmosphere. This is the argument of Douglas Reynolds and other environmentalists, when they accuse the oil sands of not being equal to crude oil.

IV. Pipelines

Pipelines provide continuous movement at a constant rate. This attribute is what makes them unique from other forms of transportation such as truck or rail. Pipelines currently transport roughly 3 million barrels per day, a number that no other form of transportation can compete with. They are a high fixed cost, and low operating cost investment. The upfront cost to build an oil pipeline is higher than any other form of oil transportation. However, once the pipeline is built, the variable cost in transporting the oil is lower than anything else. The question becomes, when does building a pipeline become cost efficient relative to other forms of transportation such as rail or truck.

In 2005, it was estimated that onshore pipelines cost an average of $1.7 million per mile (Hull 2005, 116). There are five major determinants for the fixed cost of a pipeline: mobilization of contractors, difficulty of terrain, number of compressor stations and terminals, costs of steel and welding, and the number of entry and exit points along the pipeline. These five determinants vary from project to project. In the case of the two proposed pipelines discussed in this chapter, these five determinants are extremely different.

Pipelines are the safest form of transportation of oil in the world. Hull (2005, 114) stated that less than one teaspoon of oil was spilt per thousand barrel-miles. This is because all pipelines, excluding the Alaska pipeline,[3] are below ground. This feature makes them immune to traffic accidents, and protects them from sabotage. The main safety concerns with pipelines are corrosion and construction crews breaking the pipelines. To help prevent corrosion, pipelines are coated with chemicals and have an electrical current, which flows through them to help combat erosion. Also, devices called "Smart Pigs" have been developed which flow through the pipeline with the oil. These devices detect dents and imperfections along the line and measure wall thickness to indicate areas where corrosion has occurred. To help resist against construction crews breaking the lines, all pipelines have a direct phone number to call before digging near lines. However, human error can lead to breaks in pipelines while digging.

[3] The Alaska pipeline is above ground because it would melt the permafrost.

Once pipelines are built, they instantly become natural monopolies. It would be inefficient to build two pipelines between two locations, which gives owners of pipelines a true monopoly. The Federal Energy Regulatory Commission (FERC) in the United States and the National Energy Board (NEB) in Canada regulate pricing and equality of access to the pipeline systems. Their goal is to ensure that pipeline owners, such as Enbridge and TransCanada, do not abuse their monopoly. If companies raise their prices too high, then pipelines lose their low variable cost to society. The price regulation established by these institutions is essential to make pipelines economically efficient.

Once pipelines are built, they must maximize throughput. In other words, pipelines must be full of oil from point A to point B as much as possible. One way to increase throughput is to add a drag reducing agent. This addition of lubrication along a pipeline enhances operating costs, increasing the efficiency of the pipeline.

V. The Proposed Pipelines

A. Introduction

In 2012, Canada produced 3.23 million barrels per day and CAPP estimates that by 2030, 6.7 million barrels of oil will be produced. The majority of this oil is extracted from Alberta. Yet, according to Nathan Lemphers (2013, 2), only 20 barrels per day left Western Canada by pipeline and this was mainly sent to the United States. Clearly, if Canada hopes to reach this high number, there needs to be a more efficient way to get the oil out of Western Canada and specifically Alberta. Canada also needs to find a wider range of markets for its oil. They need their oil to reach coastlines, from landlocked Alberta, where it could be transported by tankers to international destinations. The two main proposed pipelines that would do the majority of the shipping from Alberta are the Keystone XL and the Northern Gateway.

B. The Keystone XL Pipeline

The Keystone XL pipeline is one of the most debated topics in politics right now. The proposed project is a 1,179-mile, 36-inch-diameter pipeline. TransCanada, the company that would own the pipeline, estimates that the pipeline would be able to transport 830,000 barrels per day, which would revolutionize both the US and Canada's oil industry. TransCanada initially proposed the pipeline in 2008, and since then has been lobbying to get approval. On March 11 2010, the Canadian National Energy Board (NEB) approved the pipeline; however, it has yet to receive approval in the United States (as of March 9th 2014). The proposal was turned down by the US State Department but left open pending TransCanada's ability to address environmental uncertainty. CIBC (a large Canadian financial institution) estimates that there is a 50% chance that the pipeline will be built by 2020. The proposed pipeline would have a variety of positive effects for Canada, America, and international countries.

Figure 1: Map of the Keystone XL pipeline

The pipeline would begin in Hardisty, Alberta and run south, through Baker, Montana, to Steele City, Nebraska where it would connect with the current Keystone pipeline. Then from Cushing, Oklahoma, an additional extension would be built to extend the pipeline to Nederland, and Houston, Texas. Figure 1 shows the path of the proposed pipelines in dashed lines as well as the current Keystone pipeline in solid lines.

The United States is the third largest producer of crude oil in the world; however, it is the number one consumer. According to the EIA, the US produces 8.5

million barrels per day, while consuming 19.6 million. This leaves 11.1 million barrels that need to be imported each day to meet United States consumption needs. America has been shifting its energy interests from OPEC countries to Canada to cover its deficiency because Canada provides a safer and more reliable source of energy. The EIA estimates that within the last ten years Canada has become the largest supplier of oil to the United States—exceeding two million barrels per day. The Keystone XL pipeline allows the United States a reliable way for more Canadian oil to be imported, decreasing the amount of oil that would need to be imported from countries outside of North America.

During World War II, the United States divided the country into five Petroleum Administration Defense Districts (PADDs) to distribute petroleum and gasoline products. These districts are still used today and give us a loose understanding of how oil is shipped and where it is refined in the US. Currently, a large portion of Continental America's oil refining takes place in the Midwest and Gulf Coast PADDs. The Midwest PADD, as of 2011, currently imports 1.5 million barrels of oil per day from Canada, and 996 thousand barrels per day from the Gulf Coast PADD, while the Gulf Coast PADD currently meets its demand and other PADD's demands by importing from the world through the Gulf of Mexico. The Keystone XL pipeline would increase the amount of oil that the Midwest and Gulf Coast PADDs would have access to.

In 2012, the EIA estimated that oil refineries in the United States have the capability to refine 17.2 million barrels per day and are not reaching their capacity. The majority of theses refineries are in the Gulf Coast and Midwest PADDs. The

Keystone XL pipeline would increase the supply of bitumen to these refineries and get them closer to reaching their capacity.

Both the Gulf Coast and Midwest PADDs are on different price benchmarks. The Gulf Coast PADD is priced at the Brent Price, while the Midwest PADD is priced at the WTI (West Texas Intermediate) benchmark. The proposed pipeline would have the ability to bring both PADDs to the same pricing scale, allowing oil prices to become more consistent across America.

Currently the transportation of Alberta oil to coasts where it can be transported to international destinations such as Europe or Asia is miniscule. The proposed pipeline would connect Alberta oil with international countries through the Gulf of Mexico and allow Canadian oil companies to arbitrage. The Keystone XL pipeline reaching Houston, Texas would allow Alberta oil to be shipped to countries that are willing to pay the highest price for the energy.

A benefit that supporters of the project, such as US Senator John Shimkus, are magnifying to try to get the project approved is the number of jobs that building and running the pipeline creates. A large pipeline, such as the Keystone XL, creates thousands of jobs, people are needed to monitor pumping stations, maintain upkeep on the pipeline, and protect against spills. Also, thousands of additional jobs are born from the construction of the pipeline. The increased labor demand should help to stimulate the economy all along the proposed pipeline. In addition to theses jobs, Senator Shimkus is eager to point out the increased supply of safe and reliable oil from a number one trading partner that the pipeline provides.

The increased supply of reliable oil to the United States, the increased size of the market for Western Canadian oil, increased labor demand in the US, and steadied oil prices in the US are all positives of the Keystone XL pipeline. However, there are many protestors who are eager to point out the negatives of the pipeline. The majority of these negatives are environmental issues. The pipeline means a larger amount of bitumen refined in Canada and the US, leading to larger amounts of GHG released into the atmosphere. There is also the possibility of an oil spill along the pipeline or a pipeline leak that could damage the environment. Many protestors are especially worried about the Ogallala aquifer in Nebraska that provides drinking water to roughly two million Americans and supports a significant area of agriculture in the Midwest. These are just some of the potential environmental issues, and they will be discussed in greater detail later in this chapter.

C. The Northern Gateway Pipeline

The Northern Gateway pipeline has been a hot topic in Canada since Enbridge's proposal was submitted in 2008. The proposed $6 billion pipeline heads west from Alberta to the Pacific Ocean traveling a total of 1,777 kilometers. The pipeline has the ability to move 525 thousand barrels per day to the west coast of Canada. This pipeline gives Canadian oil direct access to markets all along the Pacific Ocean. In December of 2013, the NEB approved the pipeline; however, it was given hundreds of conditions that have to be met before construction can begin. The majority of these issues are discussed in this chapter.

Figure 2: Route of the Northern Gateway Pipeline

The pipeline begins just east of Edmonton, Alberta and travels west to Kitimat, British Columbia. Kitimat is a secluded inland off the Pacific Ocean that provides an ideal location for tankers to ship oil to international destinations. Figure 2 shows the path of the Pipeline.

The Northern Gateway pipeline has one major advantage over the Keystone XL pipeline—China. The Chinese National Offshore Oil Company recently purchased Nexen, a Canadian oil company, for $15.1 billion. Through this deal, China purchased ten percent of the Canadian oil sands. After the sale, their only question for the Canadian government was: how many Canadian assets could they purchase before eliciting a negative response. Clearly, the Chinese are interested in the Canadian oil market.

The EIA estimates that China will have to import 75% of its oil by 2035. For this reason they need to expand their access to oil. China owns, or has access to, 80% of the world's oil reserves and of the 20% remaining, 60% are in Western

Canada. The Northern Gateway pipeline gives China direct access to the Canadian oil sands. This could be quite troublesome for the United States because they may need to rely on some of this oil to provide for their energy shortage. This provides a strong argument for the completion of Keystone XL pipeline because of the benefit of having a consumer with a high demand.

Enbridge and other supporters of the Northern Gateway pipeline have done a more specific job of forecasting positive externalities of the project. They predict that the pipeline creates 905,000 jobs over the next 25 years in British Columbia alone. They believe that the construction, maintenance, and services that the pipeline needs provides opportunities to help the British Columbian economy flourish. They also believe that the pipeline brings Canada to the level of OPEC as an international energy supplier because of the increased ability for Canada to ship its oil outside of North America.

The resistance to the Northern Gateway pipeline comes primarily from within British Columbia. British Columbia is a province that prides itself on its environment. The province's slogan is "Beautiful British Columbia." One argument from protestors is that the pipeline diminishes the "picture perfect" environment along the pipeline path. A second argument is that the potential of an oil tanker spill near Kitimat hinders the fishing market along the west coast. Finally, protestors are making many similar arguments to those the Keystone XL protestors are using. They are worried about the additional GHG that is emitted with the additional bitumen being extracted and refined. These are the issues that protestors are magnifying in order to stop the pipeline from being built, but the Northern Gateway pipeline also has other hurdles to jump over.

First Nations or Aboriginal leaders in British Columbia are robustly opposing the pipeline. The proposed path of the pipeline travels through several Aboriginal reserves and their leaders do not feel they will receive adequate compensation for the use of their land. Essentially, they want a great deal of money for and jobs on the pipeline. The objections from these Aboriginal groups are giving Enbridge a great deal of difficulty in getting the pipeline approved. In order for the pipeline to be complete, they will have to find a way to make an agreement with these Aboriginal groups, which history has shown to be difficult.

The British Columbia government released five conditions they want met before they will allow construction of the pipeline. First, Enbridge has to meet the hundreds of conditions set by the NEB. Second and thirdly, they want world leading marine and land oil spill response, prevention, and recovery systems for British Columbia's coastlines and all along the pipeline. Fourth, the British Columbian government says that Enbridge must come to agreement with all Aboriginal groups along the pipeline. Lastly, they want a 'fair share' of the fiscal and economic benefits of the proposed oil project because of the risks they are taking with the pipeline traveling through their province. The first four conditions are manageable for Enbridge and the Alberta government; however, the fifth condition is causing a great deal of turmoil. British Columbia is demanding almost all of the royalties that Alberta would make off the oil produced and then shipped through pipeline. The

Alberta government is simply not willing to pay that much. Until this issue is resolved, the pipeline will not be constructed.

VI. Environmental issues

How do we want to leave our planet for future generations? This is the question that always arises when people think about the environment. When it comes to the oil sands, there is certainly a trade off: energy for the environment. This section is broken down into three parts: first it discusses the environmental issues with the oil sands in general, then it talks about the extra issues with the Keystone XL pipeline, and lastly it considers the environmental concerns with the Northern Gateway pipeline.

A. Oil Sands Environmental Issues

Oil sands are a much dirtier form of energy than crude oil due to the fact that the bitumen has to be extracted from the sand and other earthly materials. Then bitumen has to be refined into crude oil. The extraction of the sands from the earth uses a lot of water and the refining emits a substantial amount of carbon dioxide.

Oil sand production (extraction and refining) emits 220% to 350% more GHG than production of crude oil (Lemphers 2013, 4). The total emissions, including combustion (which is 80%), are 8% to 37% higher than crude oil. However, these numbers depend on the concentration of bitumen in the oil sand. This tends to vary depending on where the bitumen is extracted.

Canada has set goals to lower GHG emissions, yet oil sand production seems to be neutralizing and reversing these goals. Between 2010 and 2020, GHG in Canada are projected to increase by 28 Mt. In this same period, emission from the oil sands, including mining, in situ, and upgrading, are believed to increase by 56 Mt. Specifically, in situ emissions are projected to grow from 18 Mt to 55 Mt, an increase of 37 Mt in 10 years. By 2020, bitumen extraction and upgrading will make up 14% of Canada's GHG emissions. Even though GHG emission into the atmosphere is declining in nearly every other sector in Canada, oil sand emissions are making total GHG emission in Canada increase.

The main reason that Canadian oil field companies are able to emit large amounts of GHG into the atmosphere is the minimal regulation from the Albertan and Canadian governments. GHG emissions cost companies $1.80 to emit one ton of pollution into the atmosphere (Lemphers 2013, 9). This low cost gives companies little economic incentive to decrease pollution, or to find technologies that result in less GHG being emitted. It is believed that the Federal government will have oil and gas climate regulations drafted sometime in 2013, yet nothing has been released yet (as of March 10th 2014). However, if these regulations are not harsh, companies might just accept them as an increase in their variable cost. The question has to be raised, why do the provincial and federal governments have such little regulation on oil and gas climate control? One can only speculate that both the federal and provincial governments have been more concerned with increasing the amount of oil produced than they have about decreasing the effect on the environment. There is little doubt that this minimal regulation has led to economic benefits for the country (specifically Alberta), yet at what point do the environmental costs outweigh the benefits?

Despite what the above data say, there are some technological improvements in the oil sands to help reduce the effect on the environment. Supporters of the oil sands are eager to point out that since 1990, GHG per barrel of bitumen produced have decreased by 26%. New methods of in situ and mining, such as extraction by electricity, steam, and heated air, have decreased carbon emissions by up to half. Also, a study conducted by the Royal Society of Canada finds that oil sand developments have not affected ambient air quality and are not a threat to aquatic ecosystems.

There is no doubt that more can be done to limit the effect of bitumen production on the environment. It has to be noted that some technologies are being advanced and that with stricter regulation there is the possibility that more can be done.

B. Keystone XL

President Obama initially turned down the Keystone XL pipeline because of environmental uncertainty. However, he left the project open to approval pending changes from the pipeline's owner, TransCanada. Obama and others are concerned about the GHG emissions discussed above and about potential leaks and spills along the pipeline.

The primary place most American protestors are concerned about is the Ogallala aquifer, located primarily in Nebraska. The aquifer is one of the largest reserves of fresh water in America and provides fresh drinking water to roughly two million Americans. However, arguably the most important aspect of the Ogallala aquifer is it provides water to $20 billion in agriculture. Contaminating this water supply jeopardizes the industry that is the heart of the Midwest. Environmentalists are concerned because the pipeline travels through the sand hill region in Nebraska, making a spill very difficult to contain. Due to these concerns, TransCanada rerouted the course of the proposed pipeline to avoid the most vulnerable areas near the aquifer in hopes to gain approval from the United States.

There is also some discrepancy between the probability of a spill given by TransCanada and what history says the probability of a spill is. According to history, there is a 0.00109 chance of a spill per mile, whereas TransCanada believes there is a 0.00013 chance. Although these numbers look quite miniscule, there is a magnitude of ten differences is the projections. It can be speculated that the chance of pipeline spills has decreased with technologies such as electronic pipes, but whether these technologies decrease the odds by ten times is up for debate. Logically it would be wiser to use Hull's (2005, 4) estimation of one teaspoon per thousand barrel-miles to avoid the discrepancy, but often people are favorable to the side they wish to support.

Assuming the pipeline runs at full capacity all the time and that means an additional 830 thousand barrels of bitumen extracted and refined per day, equaling a 36% increase in bitumen production. This increase is equal to 6.3 coal fired power plants or 4.6 million cars on the road (Lemphers 2013, 1). A US environmental protection agency estimates that this increase leads to a 27.6 Mt increase in GHG emissions.

K. Smith (2012, 3) provides an interesting way for these environmental risks to be quantified. He suggests that investors create a bond for potential environmental damage. This gives a financial vehicle for those who are willing to assume the environmental risk. Smith estimates that the bond would have to be in the range of $11 billion to cover the risk.

In summary, environmentalists are strongly opposed to the pipeline because of the increased GHG emissions associated with the increased bitumen production and the possibility of a spill. On the other hand, most economists are mainly concerned that in the event of a catastrophic spill, the positives of the pipeline will be outweighed by the environmental damage.

C. Northern Gateway Pipeline

"Beautiful British Columbia." That's the saying British Columbia uses to advertise its province. Judging from this statement, one can imagine what British Columbia thinks about the oil sands, much less an oil pipeline splitting their province in half. It is estimated that 80% of the British Columbian population is against the Northern Gateway pipeline. Other than the objection against the GHGs emitted from the production of the oil sands, British Columbia is concerned about the possible effect of a tanker spill in Kitimat and how the pipeline affects their image as a province.

Kitimat and other cities along the Pacific Ocean rely on commercial and sport fishing to support their economies. British Columbians fear that an oil spill, either from a tanker or directly from the pipeline, could hinder the fishing market in British Columbia. A large spill on the west coast could potentially have a devastating effect on their economy.

Environmentalists opposed to the Northern Gateway pipeline have many of the same concerns as those against the Keystone XL pipeline in regard to GHG emissions. They fear the effect that the increased carbon emitted from bitumen production will have on the Canadian environment. This concern is one reason why 80% of British Columbians are resistant to the pipeline.

VII. Conclusion

The Canadian oil sands give Canada the ability to be a world-renowned economic powerhouse. In order for Canada to reach this status, the infrastructure to ship the oil to international destinations has to be improved. The Keystone XL and Northern Gateway pipelines would be a key step to improving Canada's ability to reach new markets with its oil. However, there are some high environmental hurdles that have to be overcome to make these steps a reality. The amount of GHG emitted into the atmosphere from bitumen production has to be addressed in order for many environmentalists to begin to support the Canadian oil sands. Ben Parker once said, "With great power, comes great responsibility." The oil sands have given Canada great economic power, but Canada certainly has to be responsible to its environment.

Chapter 3: Primer on Cost-Benefit Analysis

I. Introduction

Prince Gautama Siddhartha, the founder of Buddhism, once said, "After observation and analysis, when you find that anything agrees with reason and is conductive to the good and benefit of one and all, then accept it." The purpose of conducting Cost-Benefit Analysis (CBA) is to use reason to perceive whether a project is productive for an individual, company, country, and/or the world.

In CBA, costs and benefits of a public project are identified and valued from a society's perspective. Next, both the costs and the benefits are quantified and expressed into monetary units based upon social utility gains and losses. In other words, the benefits declared are the dollar amount that they increase the utility of society, whereas the costs are quantified as the dollar amount that they diminish social utility. This is a clear distinction from Cost-Revenue calculations where the costs and benefits are measured in cash flows and revenue flows. In CBA, both the future costs and benefits are discounted to reflect a single time dimension by a socially relevant discount rate. Based on these results, the project is then selected based upon the principle of maximizing the net social benefits to a society.

The remainder of this chapter is organized as follows. Section II gives the basis for CBA and discusses the economic principles. Section III examines why the perspective that the analysis is conducted from matters. Section IV is the bulk of the chapter, showing the stages of CBA and what needs to be done in each stage. Section V talks about the importance sensitivity analysis and shows two forms of it. Section VI examines why there is controversy within CBA. Finally, section VII concludes the chapter. There are also two examples, one at the end of section II and another at the end of section IV.

II. Basis of Cost-Benefit Analysis

CBA is a method uniquely designed for the evaluation of public policy. The purpose is to evaluate a project and distinguish whether the benefits outweigh the costs over a stated period of time. It can be used in a variety of different frameworks. The first, and most relevant to this paper, is the evaluation of a certain project or decision, such as the Keystone XL pipeline. CBA can also be used to distinguish between two different projects in a certain area based on a budget constraint. In this situation, CBA can help decision makers choose a project that is the most efficient use of society's resources, or the project that will give society the highest utility gain. Thirdly, the government can use CBA to distinguish whether policy changes will benefit society as a whole. The government is a regulator and provider for the economy and needs to understand how its intervention will change social utility. It can use CBA to evaluate the policies that will maximize social utility.

Welfare economics is based on a principle known as Pareto efficiency. This theory implies that any reallocation of resources in the economy is warranted if it makes at least one person better off, and does not make anyone else worse off. Once society has reached a maximum efficiency, where any further reallocation will make someone worse off, then it has reached an allocation known as Pareto optimal. One can see how this would be difficult to achieve in practice. There are very few policy decisions that make no one worse off, even if it is minimal. The Hicks-Kaldor rule was then created to be a more applicable practice.

The Hicks-Kaldor rule justifies reallocation as long as it raises the total net social benefit. If those who benefit from a policy, or a reallocation, could compensate those who lose, the policy is accepted. It must be noted that no actual compensation needs to take place. CBA is based on the Hicks-Kaldor rule. Its goal is to distinguish whether a project, policy, or decision will have an overall benefit to society. If benefactors of a reallocation win more than the losers lose, then CBA should produce a cost-benefit ratio greater than one, deeming the project productive to society.

U.S. Office of Management and Budget in the early 1990's began to make CBA instrumental in government decision-making. In 1992, they released a checklist that was in line with the economic theory surrounding CBA, known as Circular A-94.

- 1) Estimates of expected costs and benefits must be provided from the perspective of society, rather than the federal government.
- 2) Both intangible and tangible benefits and costs should be included in the analysis.
- 3) Costs should be defined in terms of opportunity costs and incremental costs and benefits rather than sunk costs and should be used in the benefit-cost computations.
- 4) Real economic values rather than transfer payments should be included in the net benefit calculation. Transfer payments may be considered and discussed in terms of distributional aspects.
- 5) In measuring the costs and benefits, the concept of consumer surplus must be employed, and when applicable willingness to pay must be measured directly and indirectly.
- 6) Market prices provide and 'invaluable' starting point for measurement, but in the presence of market failure and price distortions, shadow prices may be used.
- 7) The decision whether to accept a public project must be based on the standard criterion of net present value. To furnish additional information on the project, the internal rate of return also can be provided.
- 8) In reporting net present value and other criteria, a real discount rate of seven percent (the average pretax rate of return on average private investment in recent

years) should be used. Also, a sensitivity analysis where alternative discount rates are used should be provided.

The remainder of this chapter elaborates on these principles and goes into detail how to perform these steps in CBA.

Example 1:

For one year, a company has to make the decision whether to hire a receptionist or not. They begin by examining the costs of having a receptionist, which would be the salary of $40,000 per year. Then they have to identify the benefits. First, the receptionist would be able to answer the phones. The company estimates a benefit of $30,000 dollars per year because of the increased business associated with not missing out on potential clients. The second benefit they identify is that having a receptionist would allow the other employees to be more productive because the receptionist would be able to handle some of the clerical work. They estimate this as a benefit of $15,000.

Costs	*Benefits*
$40,000 annual salary	*$30,000 from answering the phones*
	$15,000 from doing the clerical work
$40,000 total cost	***$45,000 total benefit***

Figure 3: List of costs and benefits for example 1.

Benefit cost ratio= Present value of Benefits/ Present Value of Costs

Benefit cost ratio= $45,000/$40,000

Benefit cost ratio= 1.125

Since the benefit cost ratio is greater than one, then hiring a receptionist is worth it for this company.

This example is simplified to show the idea of CBA. In actuality, quantifying the benefits of a receptionist would be very complicated and difficult. Also, this example does not have to be discounted because the company was looking at the benefits in the first year.

III. Perspective of Cost-Benefit Analysis

When driving down a road in a town where you have never been before, and will never go again, you are much more likely to throw a piece of trash out the window than if you were in your hometown. Why? The answer to this is simple; you don't care as much about how that town looks as you do about your hometown. Your perspective on that town where you littered is different than your perspective of your hometown. In CBA, like in life, perspective matters.

In CBA, the analyst has to declare what perspective the study is being conducted from because that point of view matters in declaring what costs and benefits to include. For example, if Albany is evaluating whether to build a large stadium for a sports team, do they include the benefits that will spill over into Schenectady? This depends what perspective they are doing the study from. If they are doing the study from the point of view of Albany, they do not because Schenectady is not the analysts' concern. However, if the study were being done from the perspective of the entire Capital region (which includes both cities), then the benefits to Schenectady would be included in the calculation. The same would be true if costs are incurred from a neighboring region.

This is what is referred to as inside and outside effects. Costs and benefits of a project or policy that occur outside the specified area of the CBA are referred to as outside effects and are not included in the cost-benefit ratio calculations. On the other hand, costs and benefits that occur inside the area of the study are known as inside effects and have to be included. It is very important that these rules are followed because the inclusion of outside effects or the exclusion of inside effects can have a significant impact on the results of the study.

The perspective chosen by an analyst depends on two factors: who is paying the project, and whom the CBA is informing. The former takes into account the idea that the costs and benefits should be limited to within the specified region. If the Albany taxpayers are paying for the new sports stadium, then the CBA should be done from their perspective. It is their money that is paying for the project so, theoretically, they should not care about costs and benefits that do not occur to their community. In terms of using CBA as an informative measure for decision-making, it depends who the decision maker represents. If the stadium in Albany needs approval from the New York State government, then the CBA used to inform a state official on the project should be done from the perspective of the entire state. It would then include the benefits and costs that spillover to any other regions in the state.

IV. Stages of Cost-Benefit Analysis

There are four stages in CBA. The first, Identifying costs and benefits, is very complicated. An analyst has to be very careful to distinguish between real benefits and costs, which are relevant to the evaluation, and pecuniary effects, which harbor no net social gain. Next, the analyst has to quantify the costs and benefits. This step involves pricing both tangible and intangible effects. Then these benefits and costs need to be compared and discounted over a specified period of time. In this stage, choosing an appropriate discount rate is very important because it will have a significant impact on the results of the evaluation. Lastly, one selects the project with the highest net gain to society.

A. Identifying Costs and Benefits

In the first stage of project analysis, all relevant costs and benefits are identified and justified. Any new project draws resources from other places in society. The transfer of these factors to the new project produces output, while creating losses in other areas of the economy. The task at this stage is to identify these losses (costs) and outputs generated (benefits). The difficulty in this stage is identifying what factors to include as costs and benefits and those that need to be excluded.

There are two types of costs: direct and indirect. Direct costs are the costs immediately associated with the project or activity. Costs such as research, planning, initial capital, and operating expenses are all direct costs. Indirect costs can be thought of as costs to a third party; these are the negative externalities of a project. For example, if a city were building a subway system, an indirect cost would be the commuters who would be delayed by the construction of the transit system.

Like costs, there are also direct and indirect benefits. Direct benefits are those that occur to the users of the project and the people employed by the project who would otherwise be unemployed.[4] Indirect benefits are the positive externalities associated with the project. In the subway example, the indirect benefits would be the decrease in street traffic due to the possibility that many people who would have driven before are now able to take the subway.

Recently, there has been an increased discussion as to whether indirect benefits and costs should be included in CBA. Some argue that all but obvious indirect benefits should be excluded from the calculations and only discussed in the literature. This argument is based on the belief that there is no possible way to capture all indirect benefits and costs because there are too many of them. When certain indirect effects are included and others are excluded, it is believed that the results of the analysis will be tainted.

The difficulty with identifying costs and benefits is distinguishing between those that are welfare changing and those that are distributional effects. The former are known as real output effects. These are the costs and benefits that change the total physical production possibilities of society. Most direct effects are real output changing. Pecuniary effects are distributional effects that cause no net social welfare change. When pecuniary effects are included, double counting occurs, skewing the results of the evaluation. The argument of those saying all but obvious indirect effects should not be included is based on the assumption that these are pecuniary effects. Some believe that these effects are captured by price functions in economy. For example, say a community is deciding to renovate a beach that would bring

[4] There is an important distinction between those who would otherwise be unemployed and those who are just transferring jobs. If we assume they are transferring positions in society then we cannot count those as a benefit because there is no net social gain to society.

20,000 more people to that beach each year. One could assume that the benefit to the stores surrounding that beach should be included in the analysis because of the business they will get from the beach traffic. However, according to pecuniary effect theory, the benefit to these stores will be captured by the increase in their value. In other words, the price of owning and operating these stores will rise, so counting this a benefit will be double counting in the CBA, assuming that the value added to these stores is already included.

When identifying costs and benefits, an analyst has to be wary about the time frame they are using. They must use the with-without approach when determining costs and benefits. This means that they must determine the costs and benefits that influence net social utility with and without the project. What they must not do is identify the costs and benefits before and after the project, as this would put the analysis in two different time periods.

Lastly, costs and benefits need to be economic, not historical. For example, if a city is evaluating whether or not to tear down a building, the cost to construct the building should not be included because it is a historical cost. In a more complex example, the cost of labor to a proposed project should not be the amount that a worker earned at his previous job. Rather, it will be the output lost elsewhere in the economy because of that worker relocating. The value that the worker could generate in their next best use is the economic cost, which is then compared to the benefit of them working on the new project.

Identifying costs and benefits is a complicated process. One has to understand the factors that will change net social welfare and include those in the

CBA. However, one has to be aware of pecuniary effects and the risk of double counting. Once this process is completed, one then moves to quantifying the costs and benefits.

B. Quantifying Costs and Benefits

Once an analyst has declared all the relevant costs and benefits, he then needs to quantify them. As said earlier, costs and benefits are measured in terms of social utility gains and losses rather than cash flows or revenues. There are two types of costs and benefits: tangible and intangible. Tangible costs and benefits are those that have prices in the market. Intangible costs and benefits are those that are implicit, and do not have clear values in the market, but need to be quantified. Using the earlier subway example, a tangible cost would be the actual amount it would cost to build the subway. There is a clear price on how much the construction would cost, whereas the cost of the time commuters will be delayed by construction of the subway is an intangible cost. There is no market price that can be used to quantify the delay to commuters. When valuing an intangible cost or benefit, the analyst needs to use economic reasoning to determine the social cost.

For tangible costs and benefits, the social price is the valuation used in CBA calculations. If all the conditions of a perfect market are met—individuals are adequately informed on all possible allocation options, property rights are clearly defined, and institutional design is pursued to a level consistent with a purely competitive market—the market price equals the social price. In this state, market prices reflect marginal costs and benefits of society's output. However, this is not always the case. Often prices lack the precision of an efficient market. In these situations, market prices need to be adjusted through a process known as shadow pricing. A shadow price is a valuation that reflects the socially optimum price. For example, if Jamaica places a tax on carbon pollution at $5 per ton, then that is the market price for carbon pollution. However, society may value carbon pollution at $20 per ton based upon society's preferences. The analyst needs to use the price of $20 per ton because that will reflect the net social welfare in CBA. Using a shadow price allows an analyst to best measure the welfare changes in society.

Once a socially optimum price is determined, consumer and producer surplus is often used to determine the costs and benefit for society. Consumer surplus is a monetary measure for the maximum gain that an individual can achieve from a product at a given price. It is the difference between the amounts an individual is willing to pay for a commodity versus the amount they actually pay.

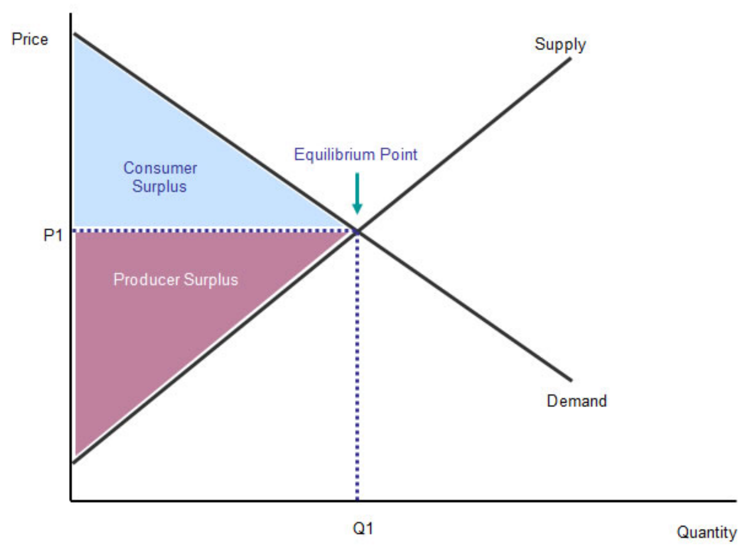

Figure 4: Consumer surplus and producer surplus

Consumer surplus is the welfare gain to consumers at the given equilibrium price. It is calculated by determining the area of the top shaded triangle in Figure 4, labeled consumer surplus. However, an ordinary demand curve assumes money income constant, and consequently consumer surplus calculations have been questioned in CBA. By definition, a price movement involves both substitution and real income effects, meaning that a price decrease will allow an individual to move to a higher indifference curve.[5] Therefore, to a obtain an exact measure of the welfare effect of a price change, one needs to eliminate the real income effect and measure only the pure substitution effect of a price change. This is observed in Figure 2 when the demand curve shifts from H to H.' Consumer surplus, even with the real income effect problem, is still a viable way to measure net welfare gains to society; however, the analyst may need to do some sensitivity analysis to be sure the results are trustworthy.

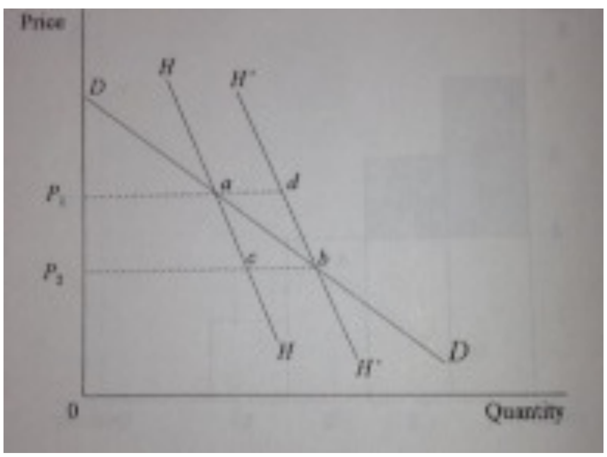

Figure 5: The elimination of the Income effect and measure of the substitution effect in a price decrease.

[5] If the price of a commodity decreases, then a person's budget constraint shifts to the right, giving them more real income and a standard demand curve does not account for this.

This limitation of consumer surplus has led to two other possible ways of measuring welfare during a price change: Compensating Variation (CV) and Equivalent Variation (EV). CV is the amount an individual is willing to pay for a price reduction, or accept for a price increase while maintaining the pre price change utility level. This represents the amount that an individual is willing to pay to have the lower price or the improved welfare. EV is the amount needed to compensate the individual who refrains from buying the good at a lower price, or the maximum amount they are willing to pay to be exempted from the higher price while remaining at the post price change real income level. When there is a price decrease or welfare improvement, EV represents one's willingness to accept an amount of income in lieu of the price change or welfare improvement. Both CV and EV capture one's willingness to pay for a price increase or welfare loss and their willingness to accept a price decrease or welfare gain. This provides us with a proper measure of welfare changes. However, authors seem to agree that both CV and EV are difficult to perform in practice and often do not perform well when used. As an analyst, one must recognize that no option is perfect, and choose the theory that works best for the evaluation.

Producer surplus is the difference between the actual price and the amount the supplier is willing to take to provide the good. It can be seen in Figure 4, as the bottom shaded triangle. When price rises, producer surplus rises and when price falls, producer surplus falls. The supply curve represents the opportunity cost of supplying an additional unit of output. The producer surplus is the difference between the market value of the factor and its opportunity cost.

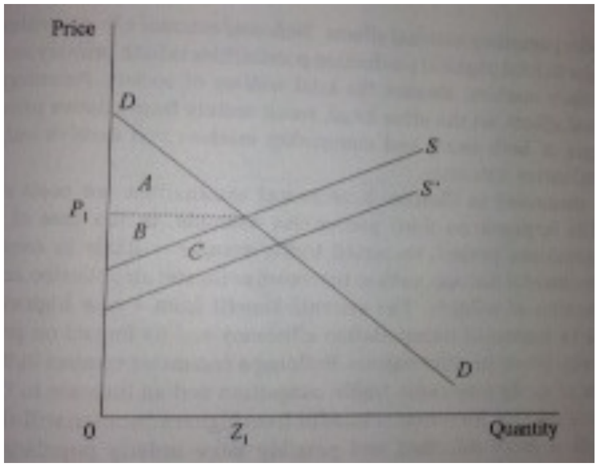

Figure 6: The welfare gain of a cost saving project.

The primary purpose of every project is to raise the level of direct output. Note that in a basic economic model, when supply is upward sloping (decreasing costs), and demand is downward sloping, the project benefits will be captured by both consumer and producer surplus. For example, say there is a cost-saving project that shifted the supply curve downward—from S to S' in Figure 6—the result would be an increase in both consumer and producer surplus. The area labeled C in Figure 3 captures this benefit.

Quantifying intangible effects is more subjective than quantifying tangible effects. The key to placing a price on these types of costs and benefits is to simply use some form of economic reasoning. One of the hardest intangible effects to quantify is the value of life. Mishan (1971) defined the value of life by using the Pareto principle—the worth of an individual's life is viewed as the minimum compensation necessary to offset the individual's non-voluntary exposure to an increased probability of death. This is just an example to show that when quantifying costs and benefits that have no market value to start from, one must find a value using economic reasoning. The contingent valuation method is another way to value intangible costs and benefits. It consists of surveying people's willingness to pay and willingness to accept, in hopes to gain values for certain intangible effects. Usually the values placed on these costs and benefits require sensitivity analysis to determine a range of values that make the project beneficial.

Quantifying costs and benefits may be the most difficult part of CBA. One has to designate a price, either through the market price or shadow pricing, for tangible effects. For intangible effects, one has to use economic reasoning to come up with a socially optimum price. Then, the analyst has to determine the net social welfare change to society through producer and consumer surplus. This is the most difficult stage of CBA.

C. Comparison of Costs and Benefits and Discounting[6]

In the third phase of project analysis, the present value of future benefits and costs of a project must be calculated and compared to the present value of investment costs. This is accomplished by discounting future net benefits by a designated factor—usually seven percent in CBA. This comparison can be done in three different ways: determining the Net Present Value (NPV) of a project, finding the Benefit-Cost ratio (B/C), and formulating the Internal Rate of Return (IRR). Each of these approaches will be explained in this section, and the advantages and disadvantages of each will be discussed.

<u>Net Present Value</u>

[6]All examples in this chapter are taken directly from Nas (1996). All credit from the calculations has to go to Nas.

In NPV, future benefits and costs are reduced to a single present dollar value (PV). The formula is as follows:

$$NPV = -Io + \sum_{n=1}^{N} NBn/((1+r)^n)$$

Where Io is the initial investment cost, r is the discount rate, NBn is the benefit stream that begins at Year 1 (n=1), and N is the projects lifetime.

The procedure of discounting is straightforward. Using a simple example, if a project yields a $10,000 benefit for the next 4 years, an initial project cost of $30,000, and an annual cost of $1,000. The benefit stream at a 6 percent discount rate will be:

PV= $10,000/(1+.06)^1+ $10,000/((1+.06)^2)+ $10,000/((1+.06)^3)+ $10,000/((1+.06)^4)

PV=$34,651

The present value of the costs will be:

PV=$1,000/(1+.06)^1+$1,000/((1+.06)^2)+ $1,000/((1+.06)^3)+ $1,000/((1+.06)^4)

PV= $3,465

One then subtracts the PV benefits from the PV costs and the initial cost of the project.

NPV= $34,651-($30,000+$3,465)

NPV=$1,186

For this simple example, the NPV is positive, which says that the project is productive. One can see how the discount rate is very important and can vastly influence the results. Throughout the literature, most economists believe that NPV is the most effective calculation.

Benefit- Cost Ratios

Benefit-Cost ratios are closely related to Net Present Values. They are used to determine the feasibility of a project during any given year or over a time span. The formula is as follows:

B/C= PV of NB/Io

Where NB is the stream of benefits net of annual operating costs, and Io is the one-time investment cost. Using the example above B/C is calculated as:

B/C= $34,651/ $33,465

B/C= 1.035

The goal of B/C is to get a ratio that will determine whether the project is profitable from a societal perspective from year to year. This particular project is deemed welfare gaining because the B/C is above one.

B/C can give different results depending on whether costs are valued as sunk costs or annual costs. Analysts have to cautious to value the costs similarly across potential projects, or the results may be skewed.

Internal Rate of Return

NPV is higher at lower discount rates. The goal of IRR is to determine the discount rate at which NPV is zero. This is the discount rate that equates the PV of future net benefits with the initial investment cost. It is calculated with the following equation:

$$0 = -Io + \sum_{n=1}^{N} NBn/((1+\pi)^n)$$

Where π is the IRR, and the other symbols are defined above. The project is deemed acceptable as long as the IRR is above the predetermined or the market discount rate. For this example, the IRR is 8.14 percent.

When the benefit stream yields different earnings each year, some positive and some negative, one can receive multiple IRR. This implies that there is more than one discount rate, making the NPV zero. This makes the results inconclusive.

Discount Rate

From the examples above, one can see how different discounts rates can influence the results of a CBA. It is important to choose a discount rate that is appropriate for one's perspective. When companies conduct a CBA, they should choose a discount rate that is similar to that of the rate of return for the market. Companies contemplating a project should realize that if their resources could yield a higher return in the market, then that is the most appropriate investment. The U.S. Office of Management and Budget, through averaging out the returns from the market for the past, believes that the best discount rate is seven percent. Literature throughout CBA tends to agree. However, it is recommended to use sensitivity analysis to distinguish the outcome of the analysis at different discount rates.

D. Project Selection

Projects should be selected based on at least one of the calculations done above. They would be accepted if the benefit cost ratio exceeds one, the net present value exceeds zero, and/or the internal rate of return is above a socially accepted rate of return. Net present value is the most reliable of these three processes; however, it can lead one astray if there is a set budget constraint. If this is the case, one has to calculate the total profit that can be made based on the results of the net present value and not necessarily rely on the project with the highest net present value calculation. A certain project may have a lower NPV, but compared to its investment cost, have a higher return on investment.

Example 2:

A city is deciding whether to renovate one of its beaches to provide a free public service to the community. Currently, the beach has 6,000 customers each year and they are charged $3 per visit for parking and other services. The owners of the beach make $.50 per visitor. After construction of the new facilities, the beach will attract 15,000 customers each year because the services will now be free of charge. The estimated cost of the project is $150,000 with an expected lifetime of 30 years. There is also a yearly maintenance cost of $15,000 per year.

First we must define the benefits.

- *The extra 9,000 attendees*
- *The first 6,000 attendees will be able to attend the beach free of charge*

Now we must define the costs.

- *The sunk cost of $150,000 for the renovation*
- *The annual cost $15,000 for maintenance*
- *The cost to the current beach owner who loses his profits*

Next we must quantify the benefits.

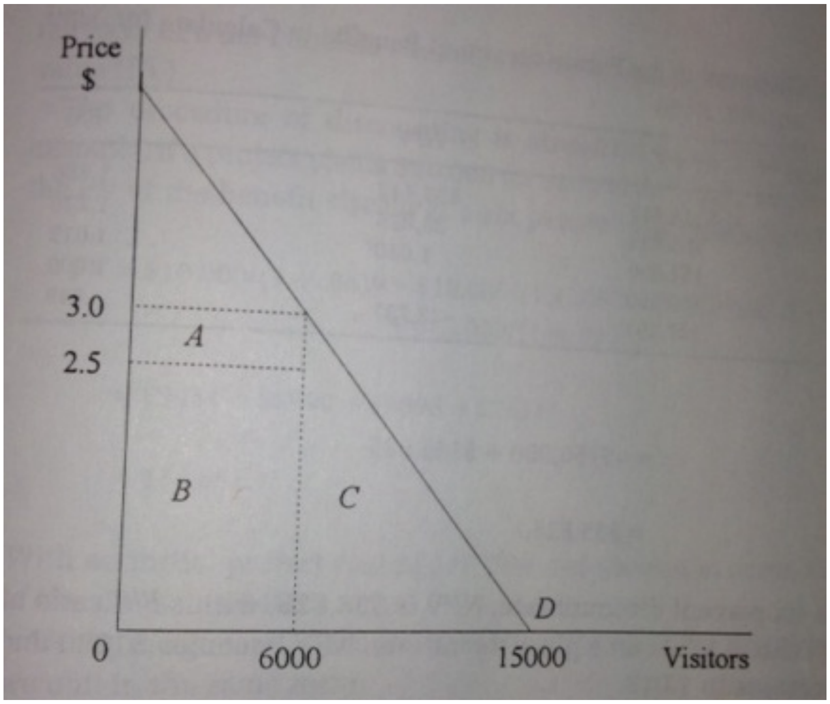

Figure 7: Example consumer surplus

- *The gains from consumer surplus of the 6,000 who attended the beach before can be quantified at $18,000. These are shown in Figure 4 by areas A and B.*
- *The benefits of the new 9,000 attendees can be calculated to be $13,500. This is shown as the area labeled C in Figure 7.*

Quantifying the costs

- *The sunk cost of $150,000 for the renovation*
- *The annual maintenance cost of $15,000*
- *The loss to the beach owner of $3,000. This is shown in Figure 4 by the area labeled A.*

Then we have to compare the costs and benefits.

Year	*0*	*1*	*2*	*30*
Benefits	*-*	*$28,500*	*$28,500*	*$28,500*
Costs	*$150,000*	*$15,000*	*$15,000*	*$15,000*

Figure 8: Comparison of Costs and Benefits

- *To get a benefit of $28,500 we combine the gains represented by area A, B, and C, while subtracting the losses of area A from Figure 4.*

Choose a discount rate: For this project, the city decided to use a lower discount rate, 6 percent, than normal because this is a public project.

Calculate Net Present Value

$$NPV = -Io + \sum_{n=1}^{N} NBn/((1+r)^n)$$

$$NPV = -\$150{,}000 + \sum_{n=1}^{30} \$13{,}500/((1+0.6)^n)$$

NPV=$35,825

Calculate Benefit-Cost ratio:

B/C= $185,825/$150,000

B/C= 1.238

Lastly one would do a sensitivity analysis on the discount rate:

Discount Rate	*PV*	*NPV*	*B/C*
4	*$233,442*	*$83,442*	*1.556*
6	*185,825*	*35,825*	*1.238*
8	*151,980*	*1,980*	*1.013*
8.14	*150,000*	*0*	*1.000*
10	*127,263*	*-22,737*	*.848*

Figure 9: Sensitivity Analysis for Discount Rate

Make a decision:

At a six percent discount rate, this project would improve the net social benefit of society.

V. Sensitivity Analysis

In CBA the outcome is often influenced by several uncertain factors. It is important to know how 'sensitive' an analysis is to a change in one of those indeterminate estimations. Whether it is through shadow pricing or quantifying an intangible variable, one cannot be sure one has the exact socially optimum price. Sensitivity analysis allows us to experiment with valuations to see how they influence the NPV of a project. The goal of sensitivity analysis is to determine the uncertainty and the risk associated with the project.

There are two main forms of sensitivity analysis: Gross and Two Variable. Gross sensitivity analysis involves calculating the change in NPV if an influencing variable changes by a given percentage. However, this will just tell us the percentage that NPV changes with the change of influencing variables. We are most interested in four factors that can be built into Gross Sensitivity Analysis:

1) What is the range of Influence? How much does the NPV change when the variable changes from its lowest plausible value to its highest plausible value?

2) Does this range of Influence contain an NPV of zero? If it does, then this variable is known as a switching variable and can change the project from being positive to negative.

3) What is the switching ratio? By what percentage does the variable have to change to hit a switching value? Also, what is this switching value?

4) What is the switching probability? How likely is the variable to reach the switching value?

All of these factors can be added into the Gross Sensitivity Analysis table as shown in Figure 5. For example, if we are evaluating whether a hospital should purchase an MRI machine and the influencing variables are insurance costs, operating costs, machine price, and usage rate, we can use sensitivity analysis to find a range in these variables.

Indicators of Sensitivity	Insurance Cost	Operating Cost	Machine Price	Usage Rate
Gross Sensitivity (10% change)	15%	21%	7%	19%
Range of Influence	10%	17%	5%	35%
Switching Value	No	Yes ($5000/day)	No	Yes (1.3 hours/day)
Switching Ratio	-	9%	-	63%
Switching	-	40%	-	42%

Probability				

Figure 10: Example of Gross Sensitivity Analysis

By scanning Figure 10, one can see that NPV is not sensitive to insurance cost and machine price since neither variable can move the NPV enough to hit the switch value. In contrast, NPV is sensitive to both operating costs and usage rate. We can say that these two variables influence the NPV roughly equally due to the switch probability being roughly the same.

On can see that Gross Sensitivity Analysis has a major flaw, it only observes changes to one variable at a time, while holding everything else constant. In reality, multiple variables will be changing simultaneously which questions the feasibility of Gross sensitivity Analysis. What if we wish to compare two variables influence on NPV simultaneously? Continuing with the MRI machine example, let us examine discount rate and usage rate.

Discount Rate	500 (h/year)	475 (h/year)	450 (h/year)	425 (h/year)	400 (h/year)
0.05	$16,814	$12,987	$9,161	$5,335	$1,509
0.06	$13,082	$9,459	$5,835	$2,212	**-$1,1411**
0.07	$9,541	$6,112	$2,683	**-$746**	**-$4,175**
0.08	$6,185	$2,941	**-$302**	**-$3,545**	**-$6,788**
0.09	$3,004	**-$61**	**-$3,127**	**-$6,192**	**-$9,257**
0.10	**-$6**	**-$2,902**	**-$5,798**	**-$8,693**	**-$11,589**

Figure 11: Example of Two Variable Sensitivity analysis.

In Figure 11, one can see how a diagonal line could be drawn to divide where NPV is positive versus where NPV is negative. Two Variable Sensitivity Analysis allows us to see how two variables can influence NPV. However, this still only allows us to compare two variables, not all the variables that influence NPV; it does not allow us to get a comprehensive understanding.

Sensitivity analysis provides a way to measure how changes in valuations will influence the results of an analysis. It allows us to understand the variables that have the most impact on the results and the variables that can switch the project from having a positive influence on society to having a negative influence.

VI. Controversy with Cost-Benefit Analysis

Since the arrival of CBA to economics and decision-making in the 1930's, it has been controversial because of the subjectivity of the process. CBA is based upon assumptions, and depending on who is doing the analysis, there are different assumptions made. There are three main pitfalls of CBA that lead to controversy each of which will be discussed below.

i. Who is doing the Cost-Benefit Analysis?

This question raises the most controversy. CBA is an expensive procedure, and who is paying for the analysis is going to influence the results. For example, in Edmonton, Alberta, Canada, there is a proposal to build a new stadium for the National Hockey League (NHL) team downtown. The NHL team hired an analyst to do the CBA and his results were outstandingly for the project. His analysis showed the benefits greatly outweighed the costs. On the other hand, the city did a CBA and found that the benefits of the stadium were negligible. The city's report showed that the stadium provided few benefits that the old stadium did not supply the city, that the new stadium would imply a large sunk cost for the new building with limited benefits to community. One can conclude that the NHL team's CBA included many indirect benefits that the city's CBA did not. This led to the completely different results. Situations like this lead to CBA not being trustworthy.

ii. Estimation

Generally speaking, the valuations for direct and tangible benefits are relatively equal across CBA. However, problems arise with indirect effects and intangible effects. Different analysts include different indirect and intangible effects into their calculations, causing different results. For example, one analyst may value carbon pollution at $12 per ton based on an increased rate of asthma patients in a given area. Another analyst may value the same carbon pollution at $30 per ton based upon the cost to extract carbon from the air. Both of these valuations have some form of economic reasoning; however, they are both extremely different and will cause very different results in one's calculation. This phenomenon is known as self-selection bias.

iii. There are no strict standards

In CBA there are no strict standards. There is no governing body or regulation in CBA. There is a general outline for CBA released by the U.S. Office of Management and Budget (shown earlier in the chapter); however, these are just guidelines. Analysts are allowed to color outside the lines. They are allowed to include costs and benefits that they feel are relevant; however, there is no system of checks and balances.

VII. Conclusion

CBA is a difficult and complicated process. To be done properly, one has to specify the perspective they are taking, then follow the four stages to carefully. Once the analyst has declared and quantified the costs and benefits, then done the calculations and determined the NPV, he has to use sensitivity analysis to show variation within his results. If done properly, CBA can be an effective tool to make decisions and help society improve its net welfare.

Chapter 4: Evaluation of the Keystone XL Pipeline

I. Introduction

The Keystone XL pipeline is one of the most controversial decisions in North America over the last five years.   Winston Churchill once said, “True genius resides in the capacity for evaluation of uncertain, hazardous, and conflicting information.” By no means does this paper assume brilliance; however, it remains rational and unbiased through its evaluation of the Keystone XL pipeline. It examines the Keystone XL pipeline using Cost-Benefit Analysis (CBA) from the perspective of Canada. All of the costs and benefits are estimated based on how they will affect Canada and the citizens of Canada over the thirty-year lifetime of the pipeline.

The remainder of this chapter is organized as follows. Section II discusses possible costs and benefits of the Keystone XL pipeline. This section also reveals whether each cost and benefit is included in the evaluation and gives the basis for why certain effects are excluded. Section III presents the assumptions made in the evaluation. Section IV includes the models. There are three models, each expanding on the previous one. Section IV concludes the chapter.

II. Costs and Benefits

As discussed in Chapter III, each cost and benefit included in the analysis has an effect on the social welfare of society. The effects that TransCanada has included in its analysis of the Keystone XL pipeline are substantially different than the effects that opponents of the pipeline have pointed out. This paper uses economic reasoning to justify the inclusion and exclusion of certain variables.

1. The Cost to Construct the Pipeline: The sunk cost of the pipeline is the main cost that is incurred. The pipeline is owned 79.99 percent by TransCanada, a Canadian company, and 20.01 percent by ConocoPhillips, an American company. From this we estimate that the cost occurring to Canada is 79.99 percent of the total cost of the pipeline. This evaluation also assumes that the financing for TransCanada to build the pipeline is coming from Canadian firms, allowing the exclusion of interest rates from the calculations.
2. Carbon Pollution: Carbon pollution is an argument often used by environmentalists against tar sands oil as a usable energy source. Carbon pollution is included in the calculations based on a progressive pricing system to cover a changing socially optimum cost. As I. Bolea, G. Ordiruca-Garcia, M. Nikoo, and M. Carbo (2013, 2765) discuss, Australia has introduced an increasing carbon fixed tax. In other words, the tax increases by 2.5 percent each year in order to capture the cost of increasing carbon levels. As carbon levels increase, the price of each additional ton has to rise due to increased health effects on society. Carbon pollution that occurs from the combustion of the oil is excluded from the evaluation because it is assumed that this will occur in the United States and will have no impact on Canada.
3. Spills: Oil pipelines often have a variety of different types of spills. A spill of over 50 barrels is referred to as a significant spill. However, estimations as to the frequency of these spills are extremely different. One has to assume that a spill can be tremendously larger than 50 barrels, such as a worst-case

scenario spill. TransCanada assumes that a worst-case scenario spill in Hardisty, Alberta is 41,504 barrels; whereas, John Stansbury (2011, 6) assumes that 87,964 barrels is a more accurate number. The difference in these estimations is due to the fact that TransCanada ignored 23 percent of the historical data in their estimation and they both predict different shutoff times for the pipeline once a spill begins. This paper agrees with John Stansbury's prediction in assuming one worst-case scenario spill every five years (every ten years in the United States and every ten years in Canada), believing this high frequency estimation will capture both the small spills and the worst-case scenario spills.

4. Benefit to Canadian Oil Companies: Assuming that the supplying companies are owned by Canadians, the benefit to oil companies is the amount of oil sold to American consumers through the Keystone XL. The profit these companies make from sales brings money into Canada, increasing Canada's social utility level.
5. Benefit to TransCanada: The benefit to TransCanada is the amount of money they make from the entire pipeline. Since TransCanada is a Canadian company, this paper assumes that the money TransCanada makes is a benefit to Canada. This effect also includes the variable cost of the pipeline because this cost is subtracted from the gross revenue of the pipeline to get net benefit.
6. Jobs: According to the Canadian Broadcasting Corporation (CBC), Canada's unemployment rate has held steady at 7 percent over recent years.

Specifically, Alberta's unemployment rate has been consistently under 5 percent. With these low numbers, one has to wonder whether the jobs created by the Keystone XL pipeline are utility gaining? Do these jobs simply transfer workers from one sector of the economy to the other, and create no real economic benefit? This paper assumes yes, because with low unemployment rates, these new jobs will not be putting the unemployed to work creating no real economic benefit.

7. Environmental Effects: Carbon pollution has already been discussed and is included in the analysis; however, something needs to be said about the damage to the land. As discussed earlier, in situ and strip mining are destructive to the land. One then has to examine the population density of Alberta (where the oil is) to understand whether this destruction is a cost. The population density in Alberta is 5.7 people per square kilometer. This cost could be compared to the saying: if a tree falls in the forest and no one is around to hear it, does it make a sound? These costs are negligible due to very few citizens being affected by the land damage.

    What about ground water and other environmental effects? Oil companies, before drilling, have to set aside money to pay for possible environmental damage. They hire environmental protection agencies, such as Worley Parsons, to monitor the ground water and clean up possible damages. This effect is included in the cost to extract bitumen and calculating it as its own cost would be double counting. Therefore, it is not included as its own cost and is assumed to be captured through including the cost of extracting bitumen.

III. List of Assumptions

Assumptions are gathered from a variety of sources and are tested through sensitivity analysis in the models.

- Price of Canadian Select Oil is $86.25.[7]
- The number of barrels sent through the pipeline is assumed to be 500,000 barrels per day (b/d). In 2009, TransCanada released that they have guaranteed contracts for $380,000 b/d to be shipped through the pipeline. Based on this guaranteed amount, we assume that 500,000 b/d is a strong estimate of what will occur consistently.
- Cost of extracting bitumen and refining it into a usable source of oil is assumed at $27 per barrel. This assumption is taken from oil-price.net and is consistent with that in the literature; however, sensitivity analysis provides us with an idea of how a variety of estimations can influence the analysis.
- Discount Rate is 7 percent based on recent literature on CBA.
- Tolls are derived from the data provided by TransCanada to the Canadian NEB in 2009. All tolls are based off the costs for heavy crude oil and are assumed on a ten-year contract to average between shipments from long-term contracts and short-term contracts.

[7] As of March 5th 2014

IV. Models

The three models presented in this chapter expand off each other. The goal is to get a basic understanding of the analysis, then to add costs to examine the decrease in Net Present Value (NPV) with each cost.

A. Model 1

The First Model gives a base understanding of the Keystone XL pipeline through comparing the sunk and variable costs of the pipeline to the benefits to Canadian oil companies and the benefits to TransCanada. This allows one to see the net social gain that the Keystone XL will bring to Canada, while ignoring the externalities such as carbon pollution and the risk of a spill.

Costs and Benefits

1. The Cost to Construct the Pipeline: TransCanada released the cost of the pipeline as 7 billion US dollars in its 2009 report to the NEB. This valuation is supported by Hull (2005, 119) who estimated that an onshore pipeline costs roughly $1.7 million per mile. This number was then transformed to Canadian dollars using the exchange rate of .90 and then to 2014 dollars.[8] This value was then multiplied by 79.99 percent because TransCanada owns this percentage of the Keystone XL pipeline. This 79.99 percent ownership means that a Canadian company will be paying for a portion of the pipeline that is in the United States so it is included in the calculations because a

[8] The exchange rate is as of March 4th 2014. Also, the conversion from 2009 dollars to 2014 dollars was done on the Bank of Canada website. This conversion rate is used throughout the rest of the paper.

Canadian company is paying for it. After the manipulations are conducted, the resulting sunk cost of the pipeline is $6.48 billion[9].

2. Benefit for Canadian Oil Companies: This benefit is derived by the following formula.

$Benefit = (\#of\ barrels\ produced\ to\ be\ shipped\ through\ the\ pipeline *$
$price\ per\ barrel\ of\ oil) -$
$(\#\ of\ barrels\ produced\ to\ be\ shipped\ through\ the\ pipeline *$
$cost\ to\ extract\ bitumen\ and\ refine\ it\ into\ a\ barrel\ of\ heavy\ crude\ oil)$

Holding all the assumptions listed in section III constant, the benefits calculated from this equation are $108,131,250,000 per year.

The cost to ship the oil through the pipeline is excluded from this calculation because it is captured in the variable cost of the pipeline, and including it here would be double counting.

3. 5. Benefit for TransCanada was derived through the equation:

$Benefit = (\#\ of\ barrels\ shipped\ through\ the\ pipeline * (total\ toll -$
$variable\ cost\ the\ ship\ the\ oil\ through\ the\ entire\ pipeline))$*(0.7999)

Total toll is derived from TransCanada's proposal to the NEB. It is estimated that they will charge $8.28 for oil to be shipped from Hardisty, Alberta to the Gulf Coast. Variable cost to ship oil through the entire pipeline is derived from the same equation and assumed to be $2.11. We believe that American consumers are paying the cost to ship the oil through the pipeline. Holding all assumptions constant, benefit for TransCanada is assumed to be $9,008,200,000 per year.

[9] This value, as well as the rest of the values in the paper unless specified, is in Canadian dollars.

This model then follows the steps listed in Chapter II.

a. List of Total Costs and Benefits

Costs	Benefits
Sunk Cost of the Pipeline $6,480,000,000	Benefit to the oil producers $108,131,250,000 per year
-	Benefit for TransCanada $9,008,200,000

Figure 12: List of Costs of Benefits for Model 1

b. Comparison of Costs and Benefits

Year	0	1
Benefits	-	$117,139,945,000
Costs	$6,480,000,000	-

Figure 13: Comparison of Costs and Benefits for Model 1

c. Calculate the Net Present Value and Benefit-Cost ratio

$$NPV = -Io + \sum_{n=1}^{N} NBn/((1+r)^n)$$

$$NPV = -\$6.48\ billion + \sum_{n=1}^{30} \$11{,}713{,}945{,}000/((1+0.6)^n)$$

$$\boldsymbol{NPV = \$136,732,000,000}$$

B/C ratio= 22.10

d. Sensitivity Analysis

The first sensitivity analysis done is a Two Variable Sensitivity analysis comparing the effects of number of barrels shipped per day and the price of oil. Figure 14 shows the NPV listed in billions of dollars and has the Benefit-Cost ratios in parentheses.

	Price of Canadian Select Oil Per Barrel						
Number of Barrels Shipped Through the Pipeline Per Day		$100/b	$90/b	$86.25/b	$80/b	$70/b	$60/b
	830,000 b/d	$283 (44.5)	$246 (38.8)	$231 (36.7)	$208 (33.1)	$171 (27.4)	$133 (21.7)
	550,000 b/d	$186 (29.5)	$161 (25.7)	$151 (24.2)	$136 (21.9)	$111 (18.2)	$87 (14.4)
	500,000 b/d	$167 (26.8)	$145 (23.4)	$137 (22.1)	$123 (19.9)	$101 (16.5)	$78 (13.1)
	450,000 b/d	$150 (24.2)	$130 (21.1)	$123 (19.9)	$110 (18.0)	$90 (14.9)	$70 (11.8)
	400,000 b/d	$133 (21.5)	$115 (18.7)	$108 (17.7)	$97 (16.0)	$79 (13.2)	$61 (10.4)
	380,000 b/d	$126 (20.4)	$109 (17.8)	$103 (16.8)	$92 (15.6)	$75 (12.5)	$58 (9.9)

Figure 14: Two Variable Sensitivity analysis of B/D and Price of Oil.

As one can see from Figure 14, even at a price of $60 per barrel of Canadian Select Oil and 380,000 barrels per day travelling through the pipeline, Model 1 produces an NPV that is positive.

For a worst-case scenario sensitivity analysis, if the cost of extraction and refining of bitumen increases to $50 per barrel, the price of Canadian Select Oil is $60 per barrel, and there are 380,000 barrels flowing through the pipeline a day, and discount rate is 15 percent, the NPV is still $7.1 billion. The Benefit-Cost ratio is 2.1.

In a best-case scenario sensitivity analysis, if cost of extraction and refining of bitumen decreases to $20 per barrel, the price of Canadian Select Oil is $100 per barrel, and there are 830,000 barrels flowing through the pipeline a day, and discount rate is 5 percent, the NPV is $381 billion. The Benefit-Cost ratio is 59.9.

Both worst-case scenario and best-case scenario sensitivity analysis are conducted on each Model to compare how the results change as costs are added.

B. Model 2

Model 2 includes carbon pollution in the evaluation. The quarrel between environmental parties and the tar sands industry concerns the carbon pollution that occurs from extraction and refining. The second change in Model 2 is the addition of a construction period. Model 1 assumed that all the construction of the pipeline occurred in year 0 and did not discount the cost of construction over the three years the pipeline takes to build. This Model also increases the length of the analysis to thirty-three years because of the addition of the three-year construction period.

Costs and Benefits

All costs and benefits from Model 1 are included in Model 2. As stated above, the cost to construct the pipeline is discounted in Model 3 to reflect the present value, assuming the pipeline takes three years to construct.

1. Carbon Pollution: I. Bolea and others (2013, 2765) estimate that each barrel of Canadian Select Oil extracted and refined produces 0.04 tons of GHG emissions (henceforth to be referred to as carbon pollution). This estimation is supported by the estimate of T. Clark, D. Gibson, B. Haley, and Jim Stanford (2013, 7) that carbon pollution from the oil field is responsible for 6.5 percent of Canada's 690 million tons of carbon pollution. Assuming that Canada is producing roughly 3.23 million barrels of oil per day, using T. Clark and others' estimation, the production of each barrel of oil produces roughly 0.037 tons of carbon emissions. This model uses I. Bolea and other's estimation that each barrel of oil extracted and refined produces 0.04 tons of carbon pollution.
    a. Price of Carbon Emissions- Greenhouse gas (GHG) emissions in Canada cost companies roughly $1.80 per ton (Lemphers 2013, 9). There is a strong argument throughout the literature on bitumen extraction that this is nowhere near the socially optimum price on GHG pollution. In 2012, Australia established a progressive fixed price for carbon pollution that will transform into flexible price regime. However, this paper assumes that the progressive fixed price regime captures the socially optimum price for carbon pollution because of the increased social cost as the amount of pollution in the air increases. In 2012, firms were charged $26.09 per ton of carbon polluted, and this number increased by 2.5 percent per year. This

paper assumes this progressive system captures the socially optimum price and is used in the calculations.

a. List of Costs and Benefits

Costs	Benefits
Sunk Cost of the Pipeline (divided into three years—0,1, and 2) $2.16 billion per year	Benefit to the oil producers $108,131,250,000 per year
Cost of Carbon Pollution $28.52 per ton beginning in year 3 and increasing by 2.5 percent per year	Benefit for TransCanada $9,008,200,000

Figure 15: List of Costs and Benefits for Model 2

b. Comparison of Costs and Benefits

Year	0	1	2	3	33
Benefits	-	-	-	$117,139,945,000	$117,139,945,000
Costs	$2.16 billion	$2.16 billion	$2.16 billion	$282,992,265	$511,469,907 Is different than year 3 because of the progressive carbon costs

Figure 16: Comparison of Costs and Benefits for Model 3

c. Calculate the Net Present Value and Benefit-Cost ratio

$$NPV = -PV\ Io + (\text{PV Benefits} - \text{PV Costs})$$

The NPV formula is manipulated because costs need to be discounted by year due to the changing cost of carbon pollution.

$$NPV = -(\$2.16billion + \frac{\$2.16billion}{(1+0.07)^1} + \frac{\$2.16billion}{(1+0.07)^2}) + (\$128{,}369{,}000{,}000 - \$2{,}973{,}939{,}541)$$

NPV=$119,330,000,000

B/C= 20.67

d. Sensitivity Analysis

The first sensitivity analysis examines how the results change if all the sunk costs occur in year 0, like in Model 1. If this is the case:

NPV=$ 118,915,000,000

B/C= 19.35

The NPV and Benefit-Cost ration decrease because benefits do not begin until year four. These results show that discounting the cost of constructing the pipeline has a minimal effect on changing the results of the analysis.

The second sensitivity analysis is a Two Variable Sensitivity analysis of discount rate and carbon tax. Figure 17 shows the NPV of the analysis in billions of dollars and Benefit-Cost ratios are in parentheses.

	Discount Rate (Percentage)						
Cost of Carbon Pollution ($/Tons)		5%	7%	9%	11%	13%	15%
	$20/ton	$157 (26.4)	$120 (20.8)	$94 (16.8)	$76 (14.0)	$62 (11.8)	$52 (10.1)
	$26.48/ton	$156 (26.2)	$119 (20.7)	$94 (16.7)	$75 (13.9)	$62 (11.7)	$51 (10.1)
	$40/ton	$154 (25.9)	$118 (20.4)	$93 (16.5)	$75 (13.7)	$61 (11.6)	$51 (10.0)
	$60/ton	$151 (25.4)	$116 (20.1)	$91 (16.3)	$73 (13.5)	$60 (11.4)	$50 (9.8)
	$80/ton	$148 (24.9)	$113 (19.7)	$89 (16.0)	$72 (13.2)	$59 (11.2)	$49 (9.6)
	$100/ton	$145 (27.4)	$110 (19.3)	$87 (15.7)	$70 (13.0)	$58 (11.0)	$48 (9.5)
	$120/ton	$142 (23.9)	$109 (18.9)	$86 (15.4)	$69 (12.8)	$56 (10.8)	$47 (9.3)

Figure 17: Two Variable Sensitivity Analysis comparing the base price of the carbon cost and the discount rate.

For a worst-case scenario sensitivity analysis on Model 2, where discount rate is 15 percent, carbon tax is $120 per ton, 380,000 barrels a day flow through the pipeline, and a cost of extraction and refining is $50 per barrel, and oil prices are down to $60 per barrel, the NPV equals $4.3 billion. The Benefit-Cost ratio is 1.07.

This result shows that even when the economic situation is at its worst, this pipeline is still beneficial for Canada, based on Model 2.

In a best-case scenario sensitivity analysis, if cost of extraction and refining of bitumen decreases to $20 per barrel, the price of Canadian Select Oil is $100 per barrel, and there are 830,000 barrels flowing through the pipeline a day, and discount rate is 5 percent, and carbon tax begins at $20, the NPV then equals $353 billion. The Benefit-Cost ratio is 58.2.

C. Model 3

Model 3 builds off Model 2 and adds spills into the calculations. As the Goo Goo Dolls once said, "everything's made to be broken" and the same is true for pipelines. Although measures are always taken to avoid spills, one must face the high probability that they are going to occur. This Model, like Model 2, also increases the length of the analysis to 33 years because of the addition of the three-year construction period.

Costs and Benefits

All costs and benefits from Model 2 are included in Model 3. These variables take the same base assumptions as in Model 2.

1. Worst-Case Scenario Spill: We assume the estimation of J. Stansbury (2011, 6) is correct because of the biases associated with TransCanada. The worst-case spill in Canada is assumed to be 87,964 barrels and in the United States is assumed to be 189,000 barrels (Sandhill region of Nebraska). This paper assumes that Canada incurs the entire cost of a spill in Canada and 79.99

percent of the cost of a spill in the United States because a Canadian company owns this percentage of the pipeline in the United States.

a. Cost to Clean up a Spill: The cost to clean up a spill is based off the tar sands pipeline spill that occurred near Kalamazoo, Michigan in 2010. The cost to clean up 19,860 barrels spilt was roughly $25 million. Based on this cost, this model assumes the cost to clean up a barrel spilt is $1258.81.

b. How long does the pipeline shut off for? In the case of the Kalamazoo spill discussed above, the pipeline owner's first action was to get the pipe back up and running. It is simple business; companies are more worried about their profits than they are about cleaning up the environment. Based on this spill, we assume that the pipeline will take a week to get back running after a spill because that was the timeframe that occurred in Kalamazoo.

a. List of Costs and Benefits

Costs	Benefits
Sunk Cost of the Pipeline (divided into three years—0,1, and 2) $2.16 billion per year	Benefit to the oil producers $108,131,250,000 per year
Cost of Carbon Pollution $28.52 per ton beginning in year 3 and increasing by 2.5 percent per year	Benefit for TransCanada $9,008,200,000 per year
Cost of Spills -Canadian $110,729,963 in years 4,14,and28 - US $237,915,090 in years 9,19,and29	-

Figure 18: List of Costs and Benefits for Model 3.

b. Comparison of Costs and Benefits

Year	0	1	2	3	4	9	33
Benefits	-	-	-	$117,139,945,000	$117,139,945,000	$117,139,945,000	$117,139,945,000
Costs	2.16 billion	2.16 billion	2.16 billion	$208,167,265	$320,009,355	$427,112,495	$436,644,907

Figure 19: Comparison of Costs and Benefits for Model 3. Costs are different due to the progressive carbon cost.

c. Calculation of Net Present Value

$$NPV = -PV\ Io + (\text{PV Benefits} - \text{PV Costs})$$

$$NPV = -(\$2.16billion + \frac{\$2.16billion}{(1+0.07)^1} + \frac{\$2.16billion}{(1+0.07)^2}) + (\$127{,}851{,}000{,}000 - \$3{,}294{,}399{,}386)$$

NPV= $118,491,000,000

B/C= 20.53

d. Sensitivity Analysis

The first manipulation to the calculations is a Two Variable Sensitivity analysis comparing the cost to clean up a barrel of oil spilt and the amount spilt effect on NPV and Benefit-Cost ratios are in parentheses. The results of this analysis can be seen in Figure 20 where NPV is listed in billions of dollars.

		Number of Barrels spilt (based on the assumptions of 189,000 barrels in the United States and 87,964 barrels in Canada)				
		-20,000 barrels	No Change	+20,000 barrels	+40,000 barrels	+60,000 barrels
Cost to clean up a barrel of oil spilt ($/b)	$1,000/b	$119 (20.5)	$119 (20.5)	$119 (20.5)	$118 (20.5)	$118 (20.5)
	$1258.81/b	$119 (20.5)	$118 (20.5)	$118 (20.5)	$118 (20.5)	$118 (20.5)
	$2000/b	$118 (20.5)	$118 (20.5)	$118 (20.5)	$118 (20.5)	$118 (20.5)
	$3000/b	$118 (20.5)	$118 (20.5)	$118 (20.4)	$118 (20.4)	$118 (20.4)
	$4000/b	$118 (20.4)	$118 (20.4)	$118 (20.4)	$117 (20.4)	$117 (20.3)

Figure 20: Two Variable Sensitivity Analysis comparing number of barrels spilt and cost to clean up a barrel spilt.

One can see from this analysis that the effects of a spill are minimal on the NPV. One has to assume this would be different if this analysis were to be conducted from the perspective of the United States due to the externalities associated with ground water in the Nebraska Sandhill region.

For a worst-case scenario sensitivity analysis, discount rate is 15 percent, carbon tax is $120 per ton, 380,000 barrels a day flow through the pipeline, cost of extraction and refining is $50 per barrel, oil prices are down to $60 per barrel, the number of barrels spilt in Canada is 147,964 and the number of barrels spilt in the United States is 249,000, and the cost to clean up a barrel spilt is $4000, the NPV then equals negative $336,461,276. The Benefit-Cost ratio is 0.94. However, if the discount rate is moved to 10 percent, then NPV equals 2.1 billion dollars and the Benefit-Cost ratio is 1.36.

In a best-case scenario sensitivity analysis, if cost of extraction and refining of bitumen decreases to $20 per barrel, the price of Canadian Select Oil is $100 per barrel, and there are 830,000 barrels flowing through the pipeline a day, discount rate is 5 percent, carbon tax begins at $20, the number of barrels spilt in the United States is 169,000 and in Canada the number of barrels spilt is 67,964, and the cost to clean up a barrel spilt is $1000, the NPV then equals $351 billion. The Benefit-Cost ratio is 57.9.

V. Conclusion

Scoring the evaluations in this chapter, one can assume that the Keystone XL pipeline is productive for Canada and its citizens. As seen in Figure 21, Model 3 shows that with the inclusion of carbon pollution from the extraction and refining of the bitumen, and the risk of spills, the pipeline has a benefit of $118 billion dollars over the thirty-year life span of the pipeline. It is also interesting to note that if oil prices drop, cost of oil production increases, and pipeline use decreases to the level of the guaranteed contracts, the pipeline is unproductive for Canada. However, economic conditions have to be severe for this to be the case. If economic conditions are favorable, then the pipeline shows immense benefit for Canada

	Potential Possibilities			
Models		Best-case scenario	Average-case Scenario	Worst-case Scenario
	Model 1	$381,392,000,000 (59.92)	$136,732,000,000 (22.10)	$7,143,000,000 (2.13)
	Model 2	$353,143,000,000 (58.24)	$119,330,000,000 (20.67)	$4,312,000,000 (1.07)
	Model 3	$351,362,000,000 (57.90)	$118,491,000,000 (20.53)	-$336,461,276 (0.94)

Figure 21: Summary of the Models and sensitivity analysis.

At this point, it has to be recognized that there had to be some critical assumptions made. The majority of these assumptions were tested; however, it is difficult to test how changing all the assumptions at once will affect the results. Through the worst-case scenario sensitivity analysis, the evaluation shows that the pipeline is not productive if the economic conditions are unfavorable.

Chapter 5: Conclusion

Rick Atkinson said, "If I've vividly laid out the narrative, the reader will come to his own conclusion." That is the goal of this thesis. The thesis identifies the issues, explains how the analysis is conducted, and then transparently conducts the calculations. The results produced in by the CBA of the Keystone XL pipeline show that it is productive for Canadian society, even with the inclusion of environmental effects and the risk of a spill.

CBA is a very controversial exercise. The estimations made on valuation in this paper are transparent and tested through sensitivity analysis; however, they can be debated. The worst-case scenario sensitivity analysis shows that the Keystone XL pipeline is productive for Canada even under difficult economic situations.

The calculations made in this paper support the decision by the Canadian NEB to approve the Keystone XL pipeline. The question then becomes, how does Canada influence the United States to get the pipeline built. As said earlier, President Obama has left the pipeline open for discussion pending on environmental review. There is similar benefit for the pipeline in United States from the perspective of oil refineries. It gives them access to additional oil to refine and sell, creating benefit for them and the United States consumers. However, TransCanada and ConocoPhillips need to find a way to deal with the environmental uncertainty. One solution could be to re-route the pipeline so it does not put the Sandhill region of Nebraska at risk. This would increase the sunk cost of the pipeline but would substantially decrease the environmental risk associated with the pipeline. According to this thesis, the benefits for the pipeline would likely still exceed the increased sunk cost of this route change.

Canada should be extending its influence on the United States to get this pipeline constructed. The estimated benefit of $118 billion dollars, according to Model 3, shows that this pipeline would provide substantial gain Canada. The extent of Canada's political influence on the United States is debatable; although, the United States could be threatened by the chance of Canadian oil going to China through the Northern Gateway pipeline as a serious threat to their energy requirements. From a Canadian perspective, this threat hopefully plays a major factor in getting the Keystone XL pipeline constructed.

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