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Impact of the Keystone XL Pipeline on North American Crude Oil Prices

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By

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Abstract

Topic: The economic impact on North American spot prices of crude oil if the Canadian and American governments accept the Keystone XL pipeline project.

This paper determines the economic impact of the TransCanada Keystone XL pipeline project. As the Keystone XL pipeline is extremely controversial it is beneficial to determine the impact on North American crude oil prices. Determining the economic impact the Keystone XL pipeline will have on crude oil prices will be a large detriment of whether the pipeline is economically beneficial. By using spot crude prices from different regions around North America and adding capacity of crude oil transmission from western Canada to southeast United States this paper determines the changes in regional spot crude oil prices. As the economic conditions in North America is still in trouble this Keystone XL project has the potential to stimulate economic growth by increasing the price in the Midwest and Canada. Environmental issues will be addressed but the focus of this paper will be an economic evaluation of the Keystone XL project. The resulting calculations show that by implementation of the Keystone XL pipeline the spread between western Canadian, WTI and Brent crude oil prices becomes smaller.

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I. Introduction

This paper will introduce and address many issues with the Keystone XL pipeline, but its primary objective will be to determine the impact that the pipeline will have on North American crude oil prices. Also, this paper will explain the background and development of the oil market around the globe and in North America to give an understanding of the crude oil market. It will address many issues that have led to the current large spread between western Canadian, WTI and Brent crude oil prices. The Crude oil market in both the United States and Canada will be analyzed to understand the basics of each crude oil market individually, and how it works together today. This will allow for greater understanding of the current status of the North American crude oil market.

This understanding of the crude oil market is essential to understanding the impacts of the Keystone XL pipeline. This paper will address specific changes in regional crude oil prices, which will have large effects on the economy of each region. The model will use a supply and demand methodology with limitation and constraints to determine changes in regional spot crude oil prices. Changes in capacity constraints will cause shocks in supply and demand in each region and will be the detriment of prices. These supply and demand shocks will be measured using long-term supply and demand curves generated for each North American region in the calculation. These changes in prices will help understand the impact of the Keystone XL pipeline on each region and its economic productivity due to these

changes in crude oil prices. The resulting calculations show numerous possible situations and the resulting price of crude oil in different regions based on the supply and demand curves.

The Calculations in this model show when the entire Keystone XL pipeline in implemented into the current market, crude prices in both western Canada and Midwestern United States increase, closing the spread between western Canada, WTI and Brent prices. These prices changes will help both western Canada and Midwestern United States economy of refiners are no longer collecting large profit margins.

II. Background Information

A. Global and North American Crude Oil Market

As Canadian crude oil production has increased over the past ten years it has become a major crude trading partner with the United States. According to US Energy Information Administration (EIA), in 2011 Canada had the third largest proven crude reserves in the world, only behind Saudi Arabia and Venezuela. This is an important factor as crude demand has continuously been growing. According to the Canadian Association of Petroleum Producers (CAPP), the Canadian oil industry is currently an $80.7 billion in revenue per year business that nationally employs 230,000 people. Canada currently has a crude production capacity of 3.23 million barrels per day, up from 3.02 million in 2011. This value is expected to continually increase as Canada accesses its approximate 175 billion barrels of proven crude reserves. Although Canada has this enormous potential of crude production, much of these crude reserves are in the western Canada oil sands, located in Alberta and Saskatchewan. These reserves are known as an unconventional source of crude. As Canada's conventional sources of crude decline, these oil sands will be relied on to maintain and increases the nations crude production. According to CAPP the oil sands account for 169 billion barrels of Canada's total crude production potential. As crude production from oil sands increases, the potential of Canada to provide crude oil to the world cannot be ignored by the United States.

Although the United States is the third largest producer of crude oil world wide, its consumption of crude is still greater than its production. According to the EIA, the United States produces 8.5 million barrels of oil per day and consumes 19.6 million barrels of crude each day. This leaves approximately 11.1 million barrels of crude being imported each day into the United States to meet its consumption. Out of the nation's current fuel consumption, petroleum and crude makes up for 40%. As the United States is the global leader in crude imports, its economy is greatly affected by the volatile prices of crude oil.

Although the consumption of crude in the United States has recently been declining due to the recent economic recession, it still greatly outweighs the nations crude production. According to Business Insider, a recent projection has the United States at an all time high production of crude oil itself. Although this estimation shows production of crude has increased, it will still not meet the enormous demand of the nation. Over the past ten years the United States has become more reliant on Canada to supply crude to meet its shortcoming. According to the EIA, Canada has become the largest supplier of crude oil for the United States in the past ten years, exceeding 2 million barrels per day for the first time ever. Along with this reliance on Canadian crude oil, the United States has become less reliant on the OPEC nations for imported crude. Over this same ten-year period the United States has declined its imports from OPEC nations by 13%. Although these numbers of declining crude supply from OPEC nations may be skewed slightly as the overall demand for crude has fallen since the 2007 economic recession, it is evident that the United States is moving towards Canadian crude instead of OPEC crude. This could add stability to

the United States crude market an in the past OPEC has manipulated price and supply and the OPEC crude oil, which has had global effects

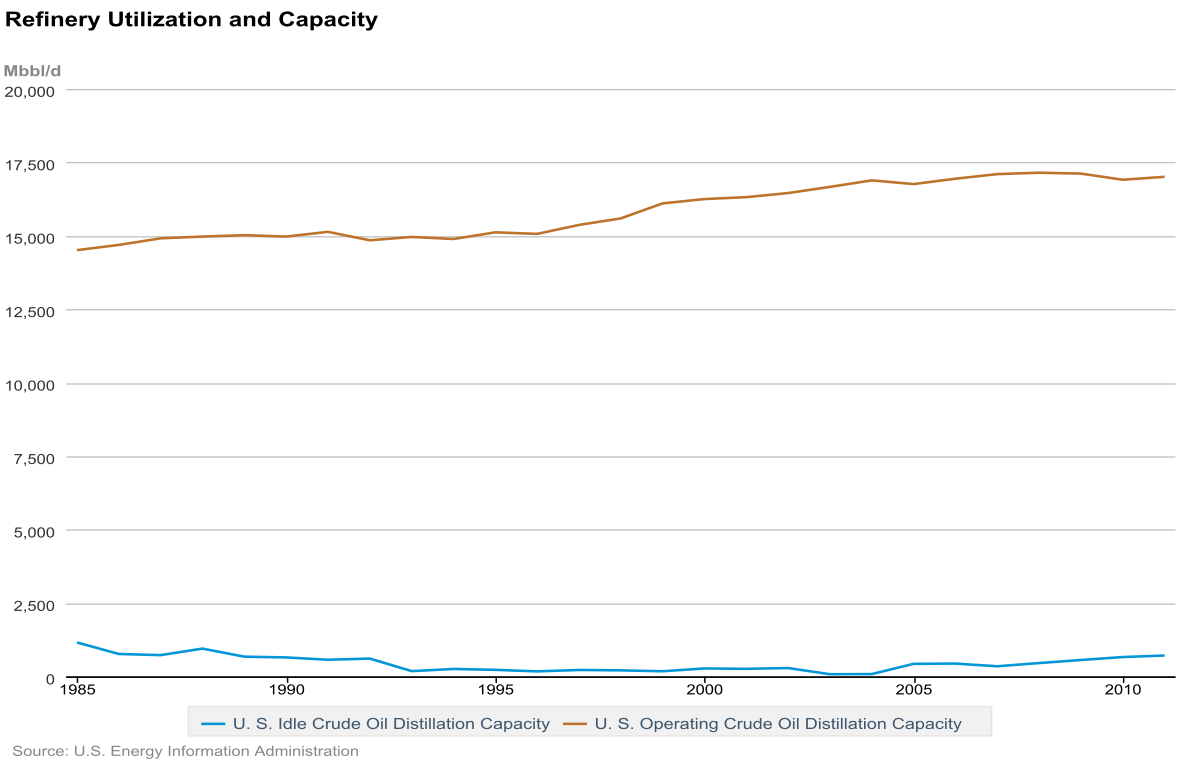
. In 1960 Iran, Iraq, Kuwait, Saudi Arabia and Venezuela joined together and created the Organization of Petroleum Exporting Countries (OPEC). This organization consisted of five large oil-producing nations and was expanded to nine other nations shortly after its establishment. With OPEC's creation and expansion the global crude market was greatly affected. Thirteen years after OPEC emerged it began to control global crude oil prices. This control of such a vast industry would become evident in 1973. During the Yom Kippur War the world saw oil prices sharply increase as an Arab oil embargo was established. Due to OPEC's vast control of the crude supply the entire globe felt this steep increase in prices. This infamous moment in history led many nations to sought out their own crude production and accumulation outside of OPEC's control and for this reason OPEC's control over the crude market has slightly declined. As of November 2010, members of OPEC control 79% of world crude reserves and 44% of the world's crude production capacity.[1]

As Canada continues to reach into its "unconventional" oil sands, it is likely that the nations crude production will continue to increase and supply crude to the United States. This will allow the United States to meet its large crude demand by importing less crude from OPEC. Also, the United States has a significant amount of idle refineries, according to the EIA the United States as of August 2012 has a refinery capacity of 17.2 million barrels per day, with approximately an idle 330 thousand barrel per day capacity. The refinery capacity in the United States has

[1] Iran Investment Monthly

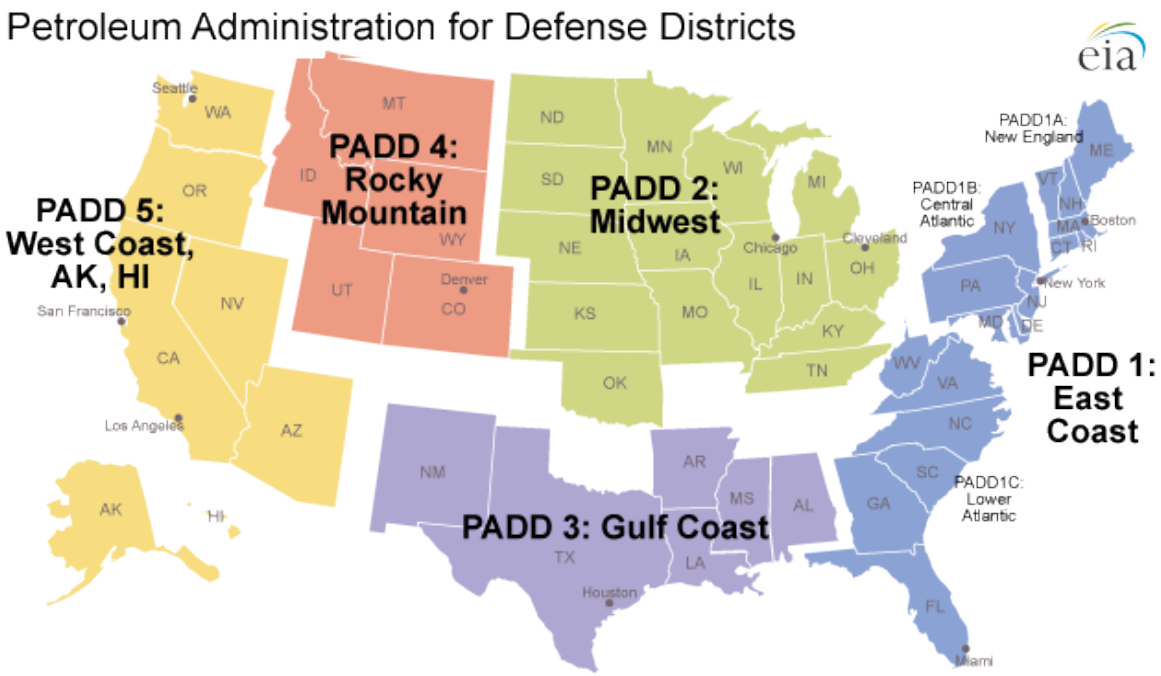
been on a gradual incline since 1985 and is expected to continue to grow as demand for refined products continues to increase. Exhibit 1 below shows the refinery capacity and total idle capacity of the United States since 1985.

Exhibit 1: Refinery Capacity and Idle Capacity of the United States, 1985-2011



The United States is separated into five different regions, called Petroleum Administration of Defense Districts (PADDs). These regions were created during World War II under the Petroleum Administration for the War to help the United States with the allocation and distribution of gasoline and petroleum products. These regions are still used today and give a basic regional distribution of crude oil production and refining data. Exhibit 2 below shows these regions.

Exhibit 2: PADD Map of United States



Source: EIA

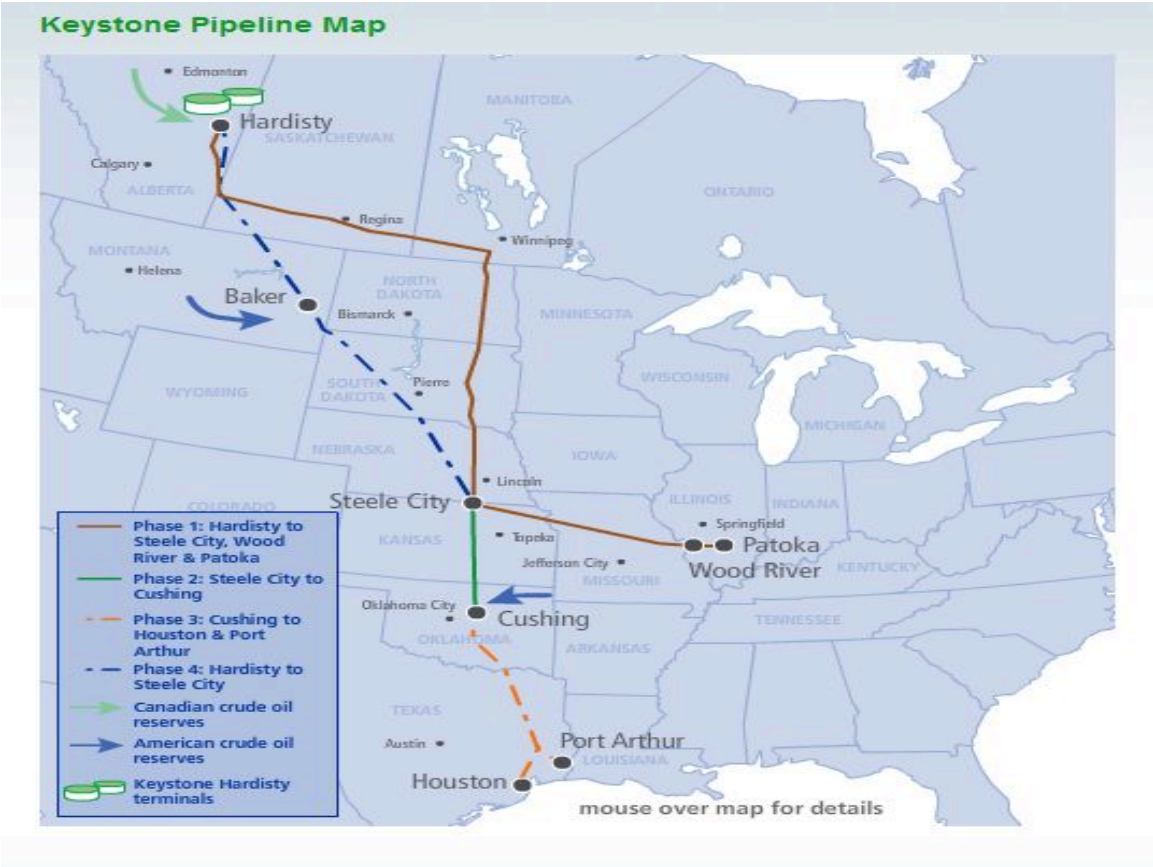
Most of the United States production of crude takes place in PADDs 2, 3 and 5. Alaskan crude production is a majority of the production in PADD 5. Although a large portion of the nations production also takes place in PADDs 2 and 3, in both of these regions the demand for crude by refineries is much greater than their supply of crude. PADD 2 is currently meeting the demands for crude through importing crude from Canada, the Atlantic Ocean and PADD 3. As of 2011 PADD 2 imported 1,553 thousand barrels of crude oil per day from Canada and 996 thousand barrels a day from PADD 3. PADD 2 crude oil is priced based on the WTI benchmark price. PADD 3 is currently meeting its excess demand of crude oil by importing crude oil from the world through the Gulf Coast. This oil is primarily priced at the Brent price, which has become significantly higher than the WTI price. This enormous refinery capacity in PADD 2 and PADD 3 would be able to refine crude incoming from western Canada, which would arrive through the new Keystone XL pipeline. This Keystone XL pipeline will bring an increase in Canadian crude oil into the United States, which would help to further reduce the United States consumption of OPEC oil.

B. History of TransCanada Corporation and Keystone XL Pipeline Project

The TransCanada Corporation proposed the Keystone XL Pipeline and has been lobbying for its approval ever since. As one of industry leaders in energy transportation in North America, TransCanada Corp. has noticed this increase in

Canadian supply of crude and the United States needs for crude oil and has used this development to stimulate North American crude oil trade. TransCanada has tried to use pipeline construction to increase energy transportation around North America to reduce excesses in supply and demand of crude in different regions. The company currently has both a network of wholly owned pipelines and a network of affiliated pipelines across North America. One of the most notable of these pipeline networks is the Keystone Pipeline. Exhibit 3 below shows the map of the current and proposed Keystone Pipeline.

Exhibit 3: Map of Keystone Pipeline and Keystone XL Pipeline



Source: NRDC Working Paper

Exhibit 3 shows both the Keystone pipeline and the proposed Keystone XL pipeline. In the Exhibit the Keystone pipeline is represented by the solid lines, phase 1 and 2, and the Keystone XL pipeline is shown in the broken lines, phase 3 and 4. The Keystone Pipeline system transports crude oil and diluted bitumen from Hardisty, Alberta to multiple destinations in the United States. The initial Keystone project, which is currently in use, transports this crude from Hardisty to refineries in Illinois and Oklahoma. This project was approved for construction in Canada on September 21, 2007. Following this approval and further debate, the American portion of this project was accepted by the United States Department of State on March 17, 2008. This initial portion of the Keystone project is referred to as Phase 1 and Phase 2. Phase 1, extending from Hardisty, Alberta to Wood River, Illinois and Patoka, Illinois is approximately 2,147 miles long. This phase became active in June 2010. Phase 2 of the project breaks from Phase 1 in Steele City, Nebraska and runs approximately 291 miles to Cushing Oklahoma. Phase 2 went online in February 2011. During the construction of these pipelines, TransCanada became the sole owner of the project when they bought out ConocoPhillips on June 17, 2009. This project took a total of six years from its proposal in 2005 to become fully operational in 2011.

The Keystone XL project provides an additional route and destinations for Canadian crude oil. Both the Keystone and Keystone XL pipelines will start at the Hardisty Terminal in Alberta, but the Keystone XL project is proposed to travel from Alberta to Texas and the Gulf Coast, which is in PADD 3., while the Keystone pipeline only reaches PADD 2. Along with crude oil being supplied from Alberta, crude oil

will also enter the pipeline in Baker, Montana to be transported to the Gulf Coast. The Keystone XL project was proposed in 2008 and was approved by the Canadian National Energy Board on March 11, 2010. Even with a Canadian approval of the project, the Environmental Protection Agency (EPA) of the United States deemed the project proposal inadequate. The United States stated the Keystone XL pipeline did not fully address safety plans and greenhouse gas concerns. TransCanada, in attempt for approval, reanalyzed the project and resubmitted a draft only to have the Department of State postpone its decision on November 10, 2011. On September 5, 2012 TransCanada again submitted a new proposal, this time with alternative routes for the pipeline. This proposal has yet to be addressed with the recent 2012 US Presidential Election.

C. Oil Market Principles

The market for crude oil has many different stages from drilling to the sale of crude to refineries. The first stage of the market is where the oil is drilled, which is called a wellhead. Drilling companies collect this crude, which is then sold to intermediary pipeline companies. The sale of this crude oil is extremely competitive and therefore the price of this sale is determined by price competition and the benchmark prices of crude. After these intermediary pipelines purchase the oil from drilling companies the crude is shipped from the wellhead locations, through small pipelines to the hubs of large, sometimes multinational pipelines, such as the

Keystone Pipeline. Once the oil has reached the large hubs the intermediary companies sell it to the large pipeline companies. After this sale, the crude is moved over large distances in large pipelines to a final destination where the crude is purchased by refineries and turned into a usable fuel source. This stage of the crude oil market the main focus of this paper as the Keystone XL pipeline will transfer crude from western Canada to the Gulf Coast. Therefore the final cost of crude is determined through a relation of the benchmark prices, cost of transmission for multiple companies and the marginal cost of drilling companies.

D. Crude Oil Pricing

To understand the basics of crude oil pricing it is essential to understand the classification of crude oil itself. Crude supplies are classified using two classifications. The first is sweet or sour. This classification depends on the sulfur content that the crude contains. Any crude oil with less than 0.42% sulfur content is referred to as sweet crude, while anything above this 0.42% sulfur content is classified as sour crude. Sweet crude is more valuable than sour crude because sweet crude has a much lower carbon dioxide content. Also sweet crude is used in the production of gasoline and therefore the demand for the sweet crude is extremely high and will remain high in the foreseeable future. The second classification of crude is heavy or light. This distinction is based on viscosity, specific gravity and API gravity of the crude. Light crude oil, which is more valuable,

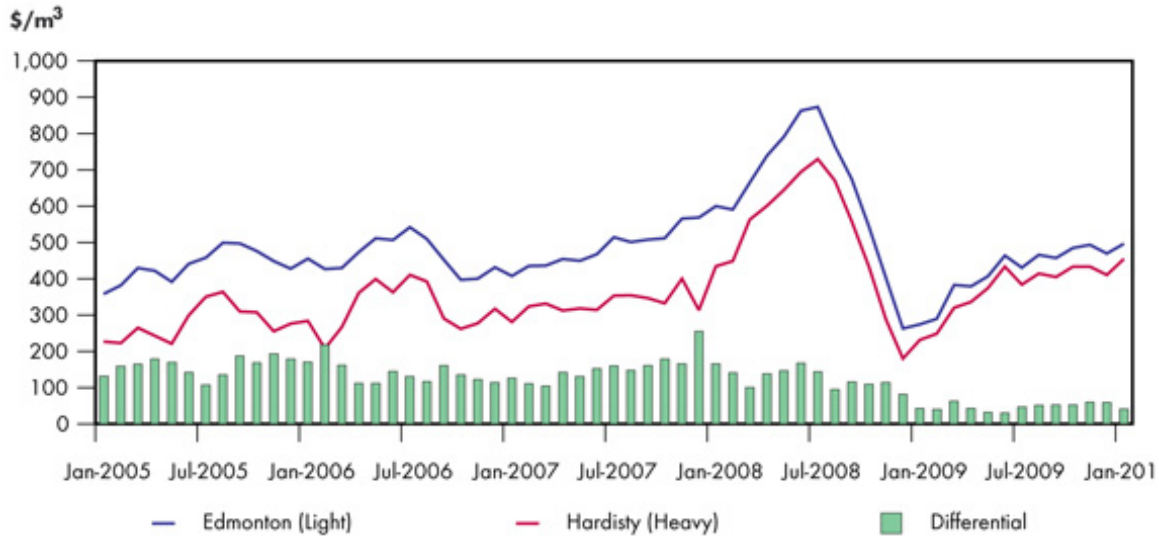
has low density and specific gravity and a high API gravity. There are different breaking points between light and heavy crude around the globe. NYMEX classification of light crude oil falls between 32° API and 42° API. Global standards are fairly similar to this classification. Light crude oil is transported easier due to its free flowing property.

After crude is classified into these two categories it is usually priced against one of the four benchmarks for crude pricing worldwide. These four benchmarks are Brent Crude, West Texas Intermediate (WTI) Crude, Dubai/Oman Crude and the OPEC Reference Basket. Brent crude is a blend that is a light sweet blend of crude. This blend is sourced from the North Sea and is mainly a benchmark for crude trade in Europe and in the Atlantic Ocean. WTI crude is also a light sweet blend of crude. This crude is mainly drilled in the southern United States and is a benchmark price for crude sold within the United States. Dubai/Oman crude is a light sour blend of crude that is drilled in Dubai. It is a price benchmark for crude in the Persian Gulf and for crude exports to Asia. OPEC reference basket price is a weighted average of the blends produced by OPEC countries. This price is a global benchmark. Although western Canadian oil does not have a benchmark price, the main pricing for light crude in western Canada follows the Western Canadian Select light blend (WCS) or sometimes called Edmonton Par. This price will be referred to as western Canadian price or WCS for the remainder of the paper. This will be the price used for the western Canadian price in this model.

For this model and calculations heavy and light crude production will be used together. This is because the price of these two divisions of crude have

mirrored each other, increasing and decreasing along similar paths. Exhibit 4 below shows the change in western Canadian heavy and light crude oil price from 2005-2011.

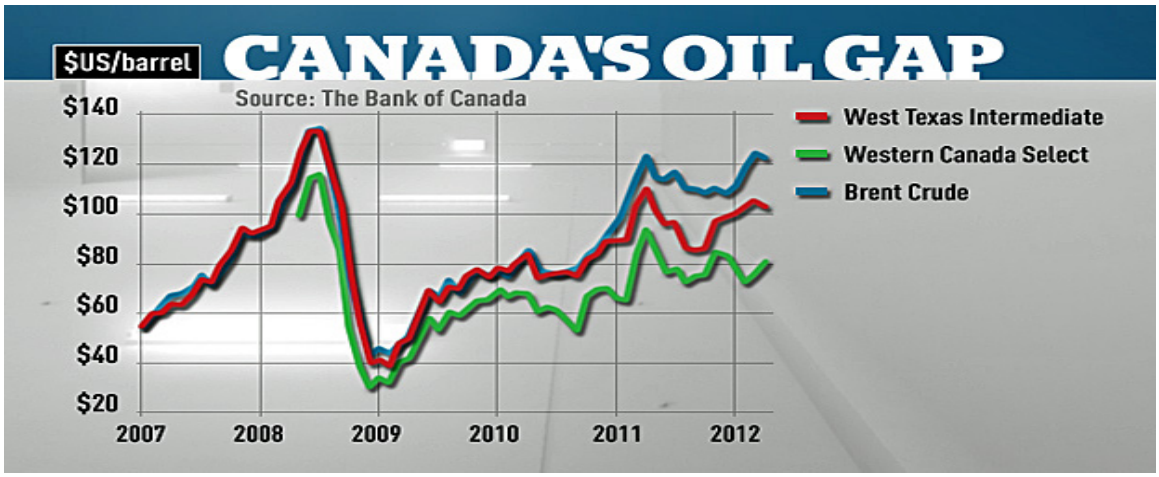
Exhibit 4: Price of Western Canada Heavy and Light Crude 2005-2011



Source: National Energy Board, Canada (NEB)

Exhibit 4 shows the changes in Edmonton light and Hardisty heavy blends of Canadian crude oil. These prices follow a similar trend and give justification for using only the light crude price in the model. This issue in North America is not the difference between heavy and light crude, but is that the prices of WCS, WTI and Brent crude have steadily been arbitraging since late 2010, while previously they have followed a similar path. This means that refiners in western Canada and PADD 2 are able to make large profit margins due a large excess supply from regional production and incoming western Canadian crude oil. PADD 3 refiners are faced with refining a large amount of crude coming from the Atlantic Ocean priced at the Brent price. Therefore, PADD 3 refiners are refining a large amount of crude at higher prices then in western Canada and PADD 2 due to a transmission bottleneck between western Canada, PADD 2 and PADD3. The Keystone XL pipeline will add capacity to the current bottleneck and reduce the arbitrage in prices. Exhibit 5 demonstrates the separation of WCS, WTI and Brent prices as explained above.

Exhibit 5: WCS, WTI and Brent Price Comparison



Source: CBC News

Exhibit 5 demonstrates how the WCS, WTI and Brent prices were extremely close from 2008 to 2010 and since then have began to spread further apart. Exhibit 5 gives a visual representation of the current problem in the North American crude oil market. As of January 2013, the price of WCS is at $89.00/bbl, the price of WTI crude is $97,00/bbl and the Brent crude oil price is $114.00/bbl.

III. Literature Review

This chapter will review numerous written literature essential to understanding the economics of the crude oil market and pipeline infrastructure. As the crude oil pipeline market in North America has developed and evolved these pipelines have become an efficient means of the transportation of crude. These pipelines are a cheap and consistent method of the transportation of crude, which would add stability to the market. Also, this crude oil market is similar to many other markets, such as the electricity market, as it is constrained by transmission capacity and cost. These capacity constraints and costs are a major determination of the price of crude oil in North America.

A. Pipeline Operations and Evolution

Hull (2005) addresses many issues related to oil pipeline operation. Hull initially shows that the transportation of crude across North America has been moving away from truck and rail cars towards a pipeline system. This is for numerous reasons. Hull states that pipelines are the safest mode of transportation throughout North America with an average of less that one-teaspoon spilled per thousand barrel-miles. This is extremely important to both the United States and Canada, as large oil spills such as the Deepwater Horizon in the Gulf of Mexico have brought up numerous cases where pipelines have caused environmental damage. Pipelines in North America, excluding the Alaskan Pipeline, are now built

underground reducing risk of spills. Also other measures such as sending an electrical current through these pipelines to halt corrosion have been taken place. As technology advances so do the pipeline systems and their resistance to spillage.

Pipelines are also very efficient in moving oil consistently and cheaply compared to other transportation systems. As oil demand is fairly predictable and demand is price inelastic, volatility in the price of oil stems usually from shortages in supply (Hull, 2005). For this reason having a reliable constant supply will help maintain sharp increases in the price of crude oil around North America. Along with this reliability of transporting crude oil, pipelines are extremely cheap compared to shipping by rail or truck. Although the cost of construction of pipelines is very large, after this sunk cost is paid, the cost of transportation is lower than that of railcar or freight. In 2001, pipelines moved 16.5% of intercity ton-miles of crude, but only accounted for 1.6% of the nations freight bill. Trucking across the United States consisted of 80.6% of the nations freight bill, while only transporting 28.1% of intercity ton-miles[2].

As pipeline transportation continues to grow as a clean and efficient mode of transporting crude across North America, regulation continues to adapt to the advances in the oil market. As many pipelines are owned by more than one private enterprise, regulations have been implemented to ensure fair and economically stable conditions for pipeline markets. The Federal Energy Regulation Commission of the United States (FERC) currently is in charge of regulating price and equality of access to these pipeline systems in the United States. As pipelines are considered a

[2] Hull, 2005. Pg 113 Table 1: Comparisons of Transportation Modes, 2002

natural monopoly, this regulation ensures prices are fair for customers and large companies cannot buy access to the limited capacity through bribery. The Federal Trade Commission (FTC) also regulates mergers of pipeline constructing companies such as TransCanada. The FTC ensures that companies that own large pipelines do not restrict access and accept bribes from large companies to shut off access to others. The FTC monitors and maintains equal access to these pipelines to help ensure a stable crude oil market

As seen in the recent attempts and failure to pass the construction of the Keystone XL pipeline, the FTC and FERC are not the only regulatory agencies that monitor pipeline construction. Numerous environmental agencies including Bureau of Land Management and Environmental Protection Agency (EPA) are also involved in this process. The two key environmental issues addressed by the EPA and environmental lobbyists with the Keystone XL pipeline are the possibility of an oil spill and the high greenhouse gas emissions associated with oil sands production. As the proposed route of the Keystone XL pipeline passes close to the Ogallala Aquifer and other wetland ecosystems a potential oil spill would pollute these ecosystems and water supplies. Also, as obtaining crude oil from oil sands in western Canada would be a large input into the Keystone XL pipeline a concern is that this would stimulate oil sands production and result in a large influx of greenhouse gases into the atmosphere. Although these environmental issues are important to the Keystone XL pipeline, this paper will be dealing with strictly the economics of the pipeline.

B. Capacity Constrained Markets and Network Industries

Hauge and Sappington (2010) address many issues and determents of price in the telecommunications and electricity markets. As both these markets share similarities it will be crucial to understand the characteristics in these capacity constrained markets. The market for electricity has numerous clear similarities with pipeline markets. One of these similarities is that at the supply end, a large number of suppliers wish to use the transmission lines to reach the demand end. This parallels that of oil markets and pipeline transmission. Also, at the demand end of the transmission line, a large number competitors wish to purchase the transmitted electrical power and distribute them it to consumers. This is similar to refineries purchasing crude oil, refining it and selling it as a finished product to retailers. Hauge and Sappington explain that regulation is needed for the transportation companies, which is similar to what Hull (2005) stated. If price of transmission for these transportation companies is not regulated then they will be able to increase prices when at capacity, which would drive prices at the demand end up and exclude many small companies from the competition of selling crude oil.

Hauge and Sappington address pricing in these network industries in as two different sections. This is the same for oil markets, as oil markets work as a competitive market at the supply end of the large pipelines. There are two markets before crude reaches the demand end of the network. These markets can be broken down into two similar markets, each with their own supply and demand ends. The supply end of the first smaller market is at the wellhead. Price of crude here is

determined through marginal cost of drilling companies, as this market is competitive. At the demand end the price of crude is determined by adding the cost of transmission. Price of crude at the demand end is again driven through competition. The supply end for the second market is at the end of the intermediary pipelines, or the demand end of the first smaller market. Price is set through competition. The demand end of the second market is at the end of the larger scale pipelines where crude is sold to the refineries. Again price is driven through competition. Therefore this mirrors the study of Hauge and Sappington and is extremely relevant to the study. The second aspect of these markets is the transmission. This part of the market requires large amounts of regulation to allow the market to operate efficiently. Transmission prices must be set and access to these modes of transmission must be equal across the supply end of the market.

The authors also address the issue of congestion in electricity transmission market. This is extremely relevant, as congestion in the crude oil market has caused a disparity between North American crude oil prices. In electricity markets transmission companies are faced with a congestion fee if they allow or promote congestion. These companies must pay this congestion fee until they expand their ability to transmit power more efficiently or increase capacity. Hauge and Sappington state that when the transmission company faces such congestion charges, it will have a financial incentive to expand the network in order to reduce congestion if and only if the associated investment cost is less than the cost imposed by congestion. The authors show this as in 2006 network capacity was added to New York City downstate region, showing a reduction in congestion costs. Although

this idea would not work with a pipeline system, due to the enormous fixed costs, the principle behind the congestion charge is the same. By adding capacity transportation it will not allow arbitrage to take place, pulling prices at the supply and demand end closer to the same amount. Although the prices will not be equal, due to the cost of transportation, it will cause prices to become closer together.

This is the main idea behind the Keystone XL Pipeline. The pipeline will increase capacity between at two areas of congestion; between western Canada and PADD 2 and also between PADD 2 and PADD 3. If the capacity is increased enough between these regions the price difference between western Canada, PADD 2 and PADD 3 will converge closer together, only differing due to the cost in transmission between the regions. Therefore this will reduce the current spread between the three prices in these regions. If the capacity of the Keystone XL is not enough and the markets are still constrained the prices will still become more equal, but will still have a difference larger then the cost of transmission.

Ruderer and Zöttl (2012) also address the importance of transmission prices and capacity place in pricing and investment in network industries. Ruderer and Zöttl establish a key difference between two types of networks; sequential market clearing and simultaneous market clearing. Global and North American oil markets are considered to be simultaneous market clearing networks as prices differentiate over regional differences. This portion of the study will be of central focus for this reason. Ruderer and Zöttl determine that simultaneous market clearing produces an optimal level of investment in transmission. They argue that in these markets

the optimal generation of capacity transmission will be established as spot prices begin to disperse far enough apart.

The study uses many different models; one of importance to the Keystone XL project is the two-node approach. This model, when approaching a simultaneous market assumes that the network is governed by competitive prices at both the supply and demand end. The difference in these prices would be the cost of transmission. The study determines that when capacity is constrained the spot prices at the demand and supply end differentiate more than the cost of transmission and therefore financing investment is needed. As oil pipelines are extremely costly to build the difference in prices and quantity at the supply and demand end must have a large difference to promote financing in capacity. As spot prices and quantity of crude in Canada and United States continue to disperse financing towards capacity is promoted. This is the current case as an independent company, TransCanada Corp., has attempted to invest in additional capacity.

Another study by Borenstein and Kellogg (2012) attempted to determine whether new investments such as the Keystone XL pipeline towards the Gulf Coast would result in a price increase of refined gasoline in the Midwestern states. The study determined that the current refineries in the Midwestern United States are currently operating at capacity. Therefore these refineries are gaining the excess rent, or profits, generated by the large difference in prices of crude and gasoline. Borenstein and Kellogg dispute the hypothesis that added transmission capacity from the Midwestern states to the Gulf Coast would result in an increase in refined gasoline prices in these states. They argue that by increasing the capacity to the Gulf

Coast it will only decrease the arbitrage in crude prices. Crude that is sitting idle in the Midwestern states will be allowed to flow towards refinery capacity in the Gulf Coast region and excess will be entered into the global crude market.

Borenstein and Kellogg show that as Canada and the Midwestern states, or PADD 2, have increased crude production a bottleneck of crude transmission has occurred. As transmission to the Gulf Coast and the rest of the world is constrained refiners in PADD 2 have been faced with an excess supply of crude, lowering the price. Although the price of crude has been lowered the pass-through of this lower crude price does not occur and refined gasoline prices have not lowered. This is, according to Borenstein and Kellogg, due to the refining capacity constraint. As refining output is maximized, the supply and demand of gasoline remains constant and therefore so does the price. With the acceptance and construction of the Keystone XL pipeline, it is likely to see this bottleneck either disappear or reduce the idle supply of crude in PADD 2. As crude can enter the pipeline in Bakers, Montana this will help to transport idle crude from the Midwest. This idle crude will join Canadian crude and travel to the Gulf Coast region, which has a large amount of refining capacity and connection to the world market. If this refinery capacity becomes fully utilized in PADD 3 then this excess supply of crude oil can be shipped worldwide by tankers, therefore increase the supply of crude in PADD 3 will help both the American and Canadian crude markets.

IV. Data

This model will use capacity changes in the crude oil market to determine the changes in regional crude oil prices. These capacity changes will essentially be shocks to supplies and demands in each region. These capacity changes will reflect the implementation of the Keystone XL pipeline. For these calculations the current trade, capacity, supply, demand and prices must be determined.

The first step in the collection of data was to determine regions that have similar prices across North America. For the United States this was basic as it is already divided in PADD regions. Canada will be split into four different regions and only two will be used in the calculations. These are western Canada, which consists of Alberta, British Columbia and Saskatchewan, and eastern Canada, which includes Manitoba, Quebec and Ontario. Exhibit 6 below shows map of Canada and each of the regions.

Exhibit 6: Regions of Canada

Source: CAPP

The data used in this project was compiled from both the CAPP and EIA government sites. All of the following representation of crude oil and capacity data in the Exhibits will be measured in thousands of barrels per day (000s bbl/day); all prices will be displayed in dollars per barrel of crude ($/bbl). The first step in the process was to determine the supply and demand of crude in each region. Exhibit 7 below shows the 2011 distribution of crude produced, or supply of crude and refinery demand of crude across Canada at current prices.

Exhibit 7: Distribution of Canadian Crude Drilling and Refining

Current Crude Oil Supply				
Canada				
	Total	WC	EC	AC
Drilled (Supply)	3281	2981	30	270
Refined (Demand)	1669	577	680	411
Net Exports	1612	2404	-650	-141

Source: Data Compiled from CAPP

Exhibit 7 shows that a large majority of Canadian crude production takes place in Western Canada. The next step to determining the current crude market is to derive the current trading capacity within the North American crude oil market. Exhibit 8 shows the current crude movement within Canada.

Exhibit 8: Crude Movement Within Canada

Western Canada To		Atlantic Canada To	
EC	AC	WC	EC
301	0	0	5

Source: Data Compiled from CAPP

Exhibit 8 demonstrates that the only significant movement of crude within Canada is from western Canada to eastern Canadian refineries. Western Canada is currently trading 301,000 barrels of crude oil per day to eastern Canada to be refined. This is total current trade taking place. For this reason eastern Canada will need to be included in the calculations for the impact of the Keystone XL pipeline. Exhibit 9 shows the distribution of Canadian crude oil exports.

Exhibit 9: Canadian Crude Oil Exports

Canadian Exports		
	Western Canada	**Atlantic Canada**
PADD 1	88	190
PADD 2	1553	
PADD 3	111	
PADD 4	207	
PADD 5	117	
Other	27	
Total	2103	190
Canadian Total		**2293**

Source: Data Compiled from CAPP

Exhibit 9 shows that of the 2,293,000 barrels per day exported from Canada that 2,103,000 barrels per day are from western Canada. Also this exhibit shows that the remaining 190,000 barrels per day from Atlantic Canada will are exported to PADD 1. As the Keystone XL pipeline will not include PADD 1 as a destination, Atlantic Canada will be excluded in the calculations. Also, as all PADD regions except PADD 2 and PADD 3 will not be directly impacted by the Keystone XL pipeline and are not a significant portion of western Canadian exports, these exports will be categorized under other exports from now on. Also exports from western Canada to PADD 3 will be considered as other exports as the crude will have to pass through PADD 2 and may not enter the Gulf Coast portion of the Keystone XL pipeline. We will assume that the current trade between western Canada and PADD 3 will continue only when the Keystone XL pipeline is at capacity and this will make total other exports from western Canada be 550,000 barrels per day. This makes

western Canadian exports be 301,000 barrels per day to eastern Canada, 1,553,000 barrels per day to PADD 2 and 550,000 barrels per day to other regions.

Another important aspect to consider in the North American crude oil market is the movement of crude within the United States. This will likely be impacted greatly by the construction of the Keystone XL pipeline and needs to be considered when determining price changes to make the calculations accurate. Exhibit 10 below shows the movement of crude oil between PADD regions of the United States and shows the net movement of all PADD regions and between PADD 2 and PADD 3 specifically.

Exhibit 10: Crude Oil Movement within the United States

United States Crude Movement Between PADD Regions					
From:	**PADD 1**	**PADD 2**	**PADD 3**	**PADD 4**	**PADD 5**
To:					
PADD 1	XXXXXXXXX	15.44	37.92	0.00	0.00
PADD 2	1.62	XXXXXXXXX	946.66	200.41	0.00
PADD 3	0.91	194.18	XXXXXXXXX	3.72	0.00
PADD 4	0.00	93.91	0.00	XXXXXXXXX	0.00
PADD 5	0.00	0.00	0.00	0.00	XXXXXXXXX
Net Movement	50.83	858.98	-785.77	-110.21	0
Net Movement from PADD 3 to PADD 2			752.48		

Source: Data Compiled from EIA

Exhibit 10 demonstrates that PADD 3's net shipment in 2011 was approximately 752,480 barrels of crude per day to PADD 2. This may seem counter productive as the excess demand for crude and the price of crude is higher in PADD 3. The reason that this trade takes place is because of the one directionality of pipelines. There is currently pipeline capacity flowing from PADD 3 to PADD 2, which is why this takes place. As this transaction is currently taking place with the price differential, we will assume this movement of crude to be at a cost of $0.00/bbl. The following calculations will not use net movement, but will include both the movement of crude from PADD 2 to and PADD 3 and from PADD 3 to PADD 2.

The next step of preparation for the calculations was gathering regional supply, demand and prices from the regions that will directly feel a large impact by the implementation of the Keystone XL pipeline. These regions will be western Canada, eastern Canada, PADD 2 and PADD 3. Exhibit 11 shows the regional supply and demand of crude for each of these regions and the current price of crude oil.

Exhibit 11: Regional Crude Oil Data

	Supply (,000 bbl/d)	Demand (,000 bbl/d)	Price ($/bbl)
Western Canada	2981	577	89.00
Eastern Canada	30	681	114.00
PADD 2	818	2479	97.00
PADD 3	3266	8486	114.00

Data Compiled from EIA and CAPP

This data shows the large price difference between western Canadian crude, PADD 2 and PADD 3 due to the large excess supply in western Canada and large excess demand in PADD 3. PADD 3 is an enormous importer of crude oil from the Atlantic Ocean and Europe and therefore takes the Brent price of $114.00/bbl. PADD 2 primarily refines crude drilled in PADD 2 and Canadian crude and takes the WTI price of $97.00/bbl. The price in western Canada will be the WCS light blend, which is $89.00/bbl. As there is currently not enough capacity to allow western Canadian crude oil to flow into PADD 2, which is why the difference in price exists between the WCS price and the WTI price. Furthermore there is also a lack in capacity for crude to travel between PADD 2 and PADD 3, which cause the price difference between WTI and Brent prices. Exhibit 12 below will show the current trade of crude by all means of transportation at its current state and the resulting net supply following trade.

Exhibit 12: Current Trade in the crude Market

Current Crude Trade				
	WC	**EC**	**PADD 2**	**PADD 3**
Supply	2981	30	828	3266
Demand	577	681	3371	8486
Excess Supply	2404	-651	-2543	-5220
Imports	0	651	2699	5102
Exports	2404	0	194	946
Net Supply After I/E	0	0	-38	-1064

Exhibit 12 shows the current trade between all regions in the calculation. Western Canada and eastern Canada currently are fully utilizing refinery capacity while PADD 2 and PADD 3 have some unused refinery capacity. Although PADD 2 has idle refinery capacity, it is only 38,000 barrels per day, while PADD 3 has 1,064,000 barrels per day of idle refinery capacity. Exhibit 13 below shows how the trading capacity between the regions will change following the implementation of the Keystone XL pipeline.

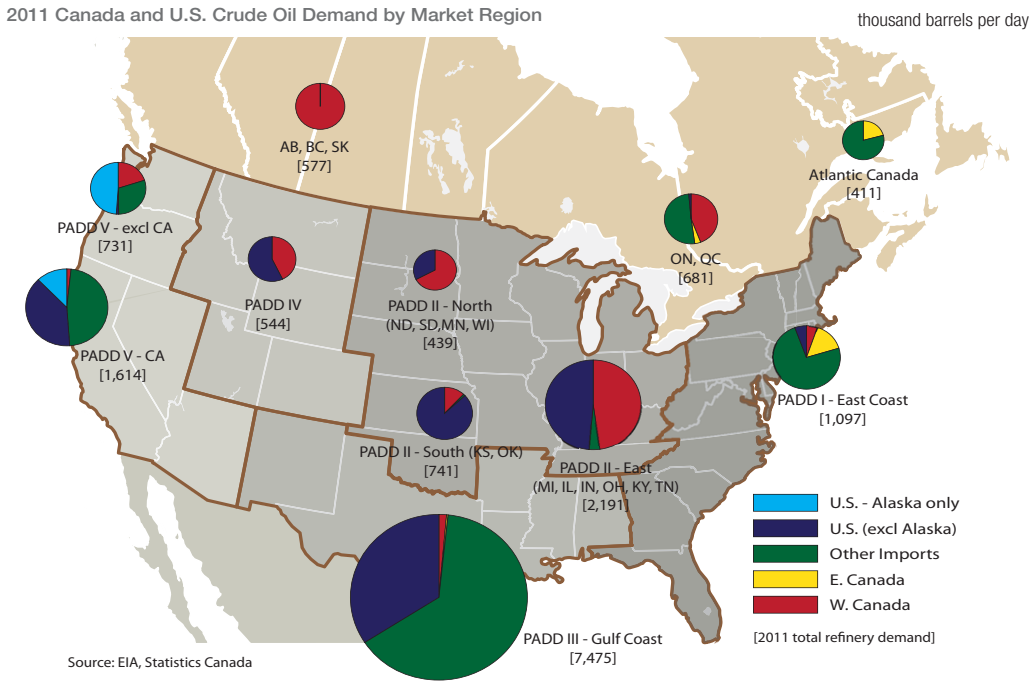
Exhibit 13: Capacity Availability Currently and After Keystone XL Construction

Origination	Destination	Before Keystone XL	After Keystone XL
Western Canada	Eastern Canada	301	301
Western Canada	PADD 2	1553	2253
PADD 2	PADD 3	194	894

Source: Data Compiled from CAPP, EIA and TransCanada Inc.

The Keystone XL pipeline would initially be a 700,000 bbl/day pipeline from western Canada to PADD 2 and an additional pipeline from PADD 2 to PADD 3 with the same capacity. North America would therefore experience an increase of 700,000 barrels per day in transportation of crude from western Canada to PADD 2 and from PADD 2 to PADD 3. Although PADD 2 will experience an increased supply of crude it will experience a decrease of supply by exactly the same amount as crude will be allowed to acesss PADD 3. Exhibit 14 below shows the current origination of crude that is being refined across North America in 2011.

Exhibit 14: Origination of Crude Refined



From exhibit 14 we can see the 2011 distribution of western Canadian crude oil throughout North America. In 2011, PADD 2 received a very small amount of global crude oil and approximately two-thirds of PADD 3 crude refined was from this global market, which is why PADD 3 will always be set to the Brent price. This assumption that PADD 3 will be set to the Brent price also assumes that no matter how much crude that PADD 3 imports, these imports will not drive the Brent price upward. By allowing crude to flow from PADD 2 to PADD 3 it would enable the price of crude to rise in PADD 2 as it will demanded from PADD 3 at a price similar to the Brent price instead of the lower WTI price.

VI. Model

The model used to determine the economic impact of the Keystone XL Pipeline will be an equilibrium model with numerous constraints. The most important constraint is trading capacity, as currently there is a large capacity blockage between western Canada and PADD 2 and also PADD 2 and PADD 3. After the data was collected the first step was to derive both a supply and demand curve. To do so price elasticity of supply and demand for crude must be determined. John C.B. Cooper (2003) using a multiple regression model estimated numerous long-run elasticities of demand for crude oil in multiple countries. From his calculations he determined the long-run price elasticity of demand for crude oil in Canada was -0.35 and was -0.45 in the United States. Noureddine Krichene (2005) using a simultaneous equations model (SEM) determined that the long-run price elasticity of supply of crude oil was 0.23. Using these values and the 2011 data of demands and supply in each region the following equations were used to determine demand and supply intercepts for each region. Exhibit 15 shows the derivation of equations used to determine these intercepts.

Exhibit 15: Demand and Supply Equations

Demand Equation:

$$Log\ (D) = D_{int} + Pe_D * Log(P)$$
$$D_{int} = Log(D) - Pe_D * Log(P)$$

Supply Equation:

$$Log(D) = S_{int} + Pe_S * Log(P)$$
$$S_{Int} = Log(S) - Pe_S * Log(P)$$

Using these equations demand and supply intercepts were determined in each of the four regions involved in the calculations. These values are shown in Exhibit 16 below with an example calculation for western Canada demand and supply intercepts.

Exhibit 16: Demand and Supply intercepts for each Region

Region	Western Canada			Eastern Canada		
	Supply	Demand	Price	Supply	Demand	Price
Current	2981	577	89.00	30	681	114.00
Intercept	3.03	3.44		1.01	3.54	
Region	PADD 2			PADD 3		
	Supply	Demand	Price	Supply	Demand	Price
Current	818	3371	97.00	3266	8486	114.00
Intercept	2.46	4.42		3.04	4.85	

Demand Intercept Calculation for Western Canada

$$Dint_{WC} = Log\ (577) + 0.35 * Log\ (89)$$
$$Dint_{WC} = 2.76 + 0.35 * (1.95)$$
$$Dint_{WC} = 2.76 + 0.68$$
$$Dint_{WC} = 3.44$$

Supply Intercept Calculation for Western Canada

$$Sint_{WC} = Log(2981) - 0.23 * Log\ (89)$$
$$Sint_{WC} = 3.47 - 0.23 * (1.95)$$
$$Sint_{WC} = 3.47 - 0.45$$
$$Sint_{WC} = 3.03$$

Calculation numbers may not add up due to rounding in these examples

Following the derivation of these intercepts we can now make basic calculations that find the equilibrium for each individual market. The next chapter will give a basic walkthrough of how to compute changes in WCS, WTI and Brent prices due to changes in capacity constraints.

VII. Calculation Basics

The following chapter will give a basic walkthrough of the process used to calculate the price changes due to the impact of the Keystone XL Pipeline. All of these calculations are long-run calculations as the elasticities used are for the calculations are long run. Although these calculations are long-run calculations supply of crude in Eastern Canada and PADD 3 will be relatively fixed as both of these regions have exhausted much of their proven crude oil supply. Western Canada and PADD 2 supply values will be allowed to increase slightly as both of these regions have proven reserves of crude oil available to them. The first two calculations that will be done only include Western Canada and PADD 2, and shows the impact that capacity constraint have on the market. Exhibit 17 below shows the first basic calculation of the two-region calculation.

Exhibit 17: Two-Region Calculation for Western Canada and PADD 2

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
After Trade						
No Capacity Constraint and a Cost of $6.50/bbl for capacity Exchange						
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3030.10	562.83	95.55	827.61	3294.87	102.05
Excess Supply	2467.26			-2467.26		
Net Supply	0.00					

The calculation in Exhibit 17 shows how the price of crude in both regions would increase if capacity was not constrained. The top half of the exhibit is the current supply, demand and price of crude oil in each region and the bottom half represents the calculation if these two regions were only able to trade with each other. By making the net supply of the two regions zero, the market is in equilibrium. The price of crude in PADD 2 will be $6.50 higher than that of western Canada due to the cost of sending crude from Western Canada to PADD 2. Although this market is in equilibrium the crude traded between the two regions is much greater than the current trade. In this market of no capacity constraint 2,476,000 barrels of crude per day will be traded from western Canada to PADD 2. Currently there is an available total trading capacity of 1,553,000 barrels per day. Exhibit 18 below shows the market equilibrium when the capacity is constrained.

Exhibit 18: Capacity Constrained Market between PADD 2 and Western Canada

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
After Trade						
Capacity Constrained at 1,553,000 bbls/day and a Cost of $6.50/bbl for capacity Exchange						
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	2370.67	817.67	32.87	952.05	2505.05	187.63
Excess Supply	1553.00			-1553.00		
Net Supply	0.00					

Although this calculation gives prices that are fairly unrealistic as the price of crude in western Canada falls to $32.87/bbl and PADD 2 price rises to $187.63/bbl, it shows the dramatic effect that a capacity constraint can have on a market. These prices in Exhibit 18 are dramatically different from current prices as this calculation assumes that the only trade that can take place is between western Canada and PADD 2, which is not the case in the market today. For this market to work in equilibrium the prices between western Canada and PADD 2 will arbitrage greatly, which is similar to what is happening between the WTI price and Brent price.

In this calculation in Exhibit 18 to determine these changes in prices the excess supply of crude in Western Canada is set to 1,553,000 barrels. The excess supply in PADD 2 will be set to a value of -1,553,000 barrels or an excess demand of 1,553,000 barrels. This is due to the fact that when capacity is not constrained between the two markets trade will be greater than the capacity available. This will be the basic structure for the following calculations. If capacity traded when it is not constrained is greater than the current capacity available in the market excess supply will be set equal to the current capacity availability to determine prices in each market. If the capacity traded when there is no constraint is less than currently available the prices will be determined by the cost of transmission through this pipeline capacity.

For the previous calculations both markets, western Canada and PADD 2, do not have sufficient access to the world market and therefore the Brent crude price will not affect the calculations. This will change when PADD 3 is put into the

calculations. As PADD 3 has open access the global market it will always meet any of its excess demand with global crude. This crude is priced at the Brent crude oil price and because of this the price of crude oil in PADD 3 will always be equal to the Brent crude oil price. This will set a price ceiling for all regions at the Brent Price, which is currently $114/bbl. Also, for the following calculations the final row will show regional excess supply following North American trade. This excess supply in eastern Canada and PADD 3 will be met with crude oil from the Atlantic Ocean. Exhibit 19 below adds PADD 3 and eastern Canada into the calculations. Exhibit 19 below demonstrates the market in the long-run under current conditions.

Exhibit 19: Four-Region Market Calculations Without Keystone XL

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC Total**
Trading Capacity	1553	194	301	946	550	2404
Cost	6.5	1.5	4	0	0	
Capacity Utilized	1553	194	301	946	550	2404
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	819.11	3362.11	97.57
Excess Supply	2404.00			-2543.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
		WC	**EC**	**P2**	**P3**	**Other via WC**
Net Imports		-2404.00	301.00	2305	-752	550
Excess Supply After NA Trade		0.00	-350.00	-238.00	-5972.00	0

This calculation shows that due a bottleneck of capacity in PADD 2 the price of crude in both PADD 2 and western Canada are significantly reduced from the Brent price. This is reflected in the recent spread between WCS light, WTI and Brent crude oil prices. This calculation includes trade by all methods of transportation, including train, truck and pipeline. This calculation shows the current market and the transactions that are taking place. Currently PADD 2 has an excess demand of

238,000 barrels per day that will be imported from a source that is not Canadian or America. This can be seen in Exhibit 14 by the small green portion in the pie chart, which shows the origination of the crude refined. Exhibit 20 below is a similar calculation, but includes the added capacity from the Keystone XL pipeline in the calculations, which increase capacity between western Canada and PADD 2 from 1,553,000 barrels per day to 2,252,000 barrels per day.

Exhibit 20: Four-Region Market Calculations With Keystone XL

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	104.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC Total**
Trading Capacity	2253	894	301	946	550	3104
Cost	6.5	1.5	4	0	0	
Capacity Utilized	2253	891	301	946	6	2560
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	3103.29	542.76	106.00	846.37	3153.46	112.50
Excess Supply	2560.54			-2307.09		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
		WC	**EC**	**P2**	**P3**	**Other via WC**
Net Imports		-2560.54	301.00	2305	-52	6
Excess Supply After NA Trade		0.00	-350.00	-2.09	-5272.00	-544

Exhibit 20 demonstrates that once the Keystone XL pipeline is constructed the price of WCS in western Canada will increase from $89.00/bbl to $106.00/bbl, and the WTI price will increase from$97.00/bbl to $102.50/bbl, reducing the spread between WCS, WTI and Brent crude. Exhibit 20 also demonstrates that the capacity from western Canada to PADD 2 is still constrained, but trade with other regions will not be constrained. This can be seen by the change in trade between western Canada and other regions. In Exhibit 19, before the Keystone XL pipeline was involved in the calculation western Canada traded 550,000 barrels of crude per day to other regions. In Exhibit 20 this number decreased to 6,000 barrels of crude per day, falling 544,000 barrels per day. This capacity will still be available but no longer utilized as it is assumed that once the Keystone XL pipeline is constructed western Canada will send crude to PADD 2 first as it will be come more costly to trade with other regions than simply using the Keystone XL pipeline, this is why there is decrease in western Canada trade with other regions. If this trade is continued to be maximized then the price in western Canada would be driven above the Brent benchmark price minus the transmission cost. This would not be possible as once this price exceeds this price of $106/bbl (Brent price of $114/bbl minus the transmission cost of $8/bbl) PADD 2 would no longer trade with western Canada. For this reasoning the trade between western Canada and PADD 2 would be at capacity, but in a state that does not allow prices to arbitrage as western Canada total trade is not at capacity. Also, in this calculation the Gulf Coast portion of the Keystone XL pipeline is near full utilization as the increase in price in PADD 2 due to relieving this bottleneck results in a slight decrease in the demand of crude and

slight increase in the supply of crude in PADD 2. The excess demand in PADD 2 decreases by 236,000 barrels per day. Due to this decrease the PADD 2 excess demand is satisfied from the 946,000 barrels per day from PADD 3 and 1,361,000 barrels of western Canadian crude. This leaves 892,000 barrels of western Canadian crude to flow in PADD 3 through current capacity of 194,000 barrels per day and the addition 700,000 barrels per day of the Keystone XL Gulf Coast portion.

VIII. Policy Variations and Implications

This chapter will involve calculations, which include numerous scenarios that are currently under debate. Examples of these calculations will give a basis for how to manipulate the model to use for numerous changes in crude oil trade and policy changes. The first issue to address is the failure for approval of Phase 4 of the Keystone XL pipeline from Hardisty Alberta to Steele City. As TransCanada is currently debating whether to go forward with the Gulf Coast section without the approval of Phase 4, this is a very possible scenario. This scenario will change the trading capacity between PADD 2 and PADD 3 while leaving the capacity between western Canada and PADD 2 the same. The capacity available between western Canada and PADD 2 will remain at 1,553,000 barrels per day, while the trading capacity between PADD 2 to PADD 3 will increase by 700,000 barrels per day from the currently available capacity of 194,000 barrels per day to 894,000 barrels per day. Exhibit 21 below demonstrates the market changes that will take place if this scenario becomes reality.

Exhibit 21: North American Crude Oil Market with only Gulf Coast Expansion

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	104.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC Total**
Pipeline Capacity	1553	894	301	946	550	2404
Cost	6.5	1.5	4	0	0	
Capacity Utilized	1553	192	301	946	550	2404
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	846.37	3153.46	112.50
Excess Supply	2404.00			-2307.09		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
		WC	**EC**	**P2**	**P3**	**Other via WC**
Net Crude Traded		-2404	-301	1605	-52	550
Excess Supply After Trade		0.00	-350.00	-702.09	-5272.00	0

Exhibit 21 demonstrates the implications of not constructing phase 4 of the Keystone XL. This policy decision would allow PADD 2 price to increase from $97.00/bbl to $112.50/bbl, while the price of crude in western Canada will remain the same at $89.00/bbl. Therefore this policy will allow the spread between WTI and Brent prices to become smaller, while the spread between western Canadian crude price and WTI will increase. This is due to the currently constrained capacity

between Western Canada and PADD 2 will not increase with this policy, only the capacity between PADD 2 and PADD 3 would increase. Although this capacity increased it will not be fully utilized. Only 192,000 barrels per day of the available 894,000 barrels per day will be utilized.

The next example will be if the Keystone XL pipeline project was constructed and the reversals of current Gulf Coast pipelines take place. As the bottleneck continues to increase between PADD 2 and PADD 3 this reversal is likely to take place and allow 400,000 barrels per day to stop flowing from PADD 3 to PADD 2 and instead increase capacity between PADD 2 to PADD 3 by the same value. Exhibit 23 below will demonstrate this change in the crude oil market.

Exhibit 23: Gulf Coast Pipeline Reversals and Keystone XL Pipeline

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	104.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC Total**
Pipeline Capacity	2253	1294	301	546	550	3104
Cost	6.5	1.5	4	0	0	
Capacity Utilized	2253	492	301	546	6	2560
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	3103.29	542.76	106.00	846.37	3153.46	112.50
Excess Supply	2560.54			-2307.09		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
		WC	**EC**	**P2**	**P3**	**Other via WC**
Net Crude Imported		-2561	301	2799	-55	6
Excess Supply After Trade		0.00	-350	0.91	-5275.00	-544

From Exhibit 23 we see that PADD 2 is now able to successfully meet its total demand for crude. Although PADD 2 is doing so, the full capacity of the Keystone XL Gulf Coast project and the pipeline reversal is not being used. In this calculation we see that PADD 2 has a net increase in crude supply of 2,799,000 barrels per day. Of this net increase 2,253,000 barrels per day will come from western Canada, leaving

546,000 barrels per day to be imported from PADD 3. This leaves 492,000 barrels per day of excess crude in PADD 2 to flow to PADD 3, while the capacity available is 1,294,000 barrels per day. If both the Keystone XL Pipeline and the pipeline reversal between PADD 3 and PADD 2 took place it will promote drilling to increase in both western Canada and PADD 2. Therefore this scenario will help to stimulate both the Canadian and PADD 2 crude drilling.

The next example will demonstrate the previous calculation in Exhibit 23, but will include an estimated increase in supply in PADD 2. This estimation is using the published data available from 2012 from January to October. This data shows that drilling of crude has increased in PADD 2 due to increased drilling in the Bakken area. Although this is not an annual barrel per day production, it will give a rough calculation of the results using an increase in supply of PADD 2 crude oil. The rough estimation increases supply of PADD 2 crude oil to 1,109,000 barrels per day. Exhibit 24 shows this calculation.

Exhibit 24: North American Crude Market with Keystone XL, Pipeline Reversal and Increased PADD 2 Supply

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	1109.00	3371.00	97.00
Excess Supply	2404.00			-2262.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	104.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC total**
Pipeline Capacity	2253	1294	301	546	550	3104
Cost	6.5	1.5	4	0	0	
Capacity Utilized	2253	793	301	546	6	2560
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	3103.29	542.76	106.00	1147.46	3153.46	112.50
Excess Supply	2560.54			-2006.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
	WC	**EC**	**P2**	**P3**	**Other**	
Net Crude Imported	-2561	301	2006	247	6	
Excess Supply After Trade	0.00	-350.00	0.00	-4973.00	-544	

Exhibit 24 demonstrates the changes in the market following the increased supply in PADD 2. This increase in supply in PADD 2 will increase the amount of crude that is shipped to PADD 3 through the Keystone XL Gulf Coast pipeline and the pipeline reversal. Assuming that the PADD 2 will still import 546,000 barrels per day from PADD 3, PADD 2 will now be able to ship excess western Canadian crude oil and any excess PADD 2 supply to PADD 3. This can be seen through the increase

in PADD 3 net crude imports to 247,000 barrels per day. As PADD 2 will have an excess demand of 2,006,000 barrels per day and are receiving 546,000 barrels from PADD 3 and only 1,463,000 barrels of crude from western Canada will be needed in PADD 2. This allows 793,000 barrels of western Canadian crude to flow through the Keystone XL Gulf Coast pipeline and the pipeline reversal project causing the net crude imports from PADD 3 to be 246,000 barrels per day. As crude supply in western Canada is expected to increase as oil sands production increases, the crude that PADD 3 is receiving from western Canada will likely increase as well.

The final calculation will demonstrate how to manipulate the model for changes in the price elasticity of supply and demand. In this calculation both the price elasticity of supply and demand will become more elastic. The price elasticity of supply will be changed from the current value of -0.23 to -0.30. The price elasticity of demand in Canada will be change from 0.35 to 0.40 and in the United States from 0.45 to 0.50. These changes will require new calculations of the demand and supply intercepts for all the regions involved. The calculations are similar to those in Exhibits 15 and 16. The new intercepts for each region are shown in Exhibit 25 below.

Exhibit 25: Change Demand and Supply Intercepts

Region	Western Canada			Eastern Canada		
	Supply	Demand	Price	Supply	Demand	Price
Current	2981	577	89.00	30	681	114.00
Intercept	2.89	3.54		0.87	3.64	
Region	PADD 2			PADD 3		
	Supply	Demand	Price	Supply	Demand	Price
Current	818	3371	97.00	3266	8486	114.00
Intercept	2.32	4.52		2.90	4.96	

Using these new intercepts in we will calculate the changes in the price of crude in the four regions if the Keystone XL pipeline in constructed. This calculation will show the current state and then the change following the implementation of the Keystone XL pipeline. Exhibit 26 below shows the calculation.

Exhibit 26: Implementation of Keystone XL pipeline with New Elasticities

	Western Canada			PADD 2		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	2981.00	577.00	89.00	818.00	3371.00	97.00
Excess Supply	2404.00			-2553.00		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
After Trade						
	WC to P2	**P2 to P3**	**WC to EC**	**P3 to P2**	**WC to Other**	**WC total**
Pipeline Capacity	2253	894	301	946	550	3104
Cost	6.5	1.5	4	0	0	
Capacity Utilized	2028	894	301	946	274	2603
	Western Canada			**PADD 2**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Current	3141.50	538.03	106.00	855.20	3130.17	112.50
Excess Supply	2603.46			-2274.97		
	PADD 3			**Eastern Canada**		
	Supply	**Demand**	**Price**	**Supply**	**Demand**	**Price**
Equilibrium	3266.00	8486.00	114.00	30.00	681.00	114.00
Excess Supply	-5220.00			-651.00		
		WC	**EC**	**P2**	**P3**	**Other via WC**
Net Crude Traded		-2603.46	301	2305	-52	49.46
Excess Supply After Trade		0.00	350.00	30.03	-5272.00	-500.54

Exhibit 26 shows the market if price elasticity of supply and demand are changed. The prices in this market will be the same as when the original elasticities are used, but there is a change in the ending excess supply after trade. As PADD 2 excess supply before trade is lower then with the original elasticities, PADD 2 will import less crude from western Canada. In this calculation PADD 2 is only importing 1,328,000 barrels per day from western Canada compared to 2,253,000

barrels per day, a decrease in 925,000 barrels per day. This will allow western Canada to send this excess 700,000 barrels per day to PADD 3 through the Keystone XL pipeline. These different elasticities will also change the utilization of the trading capacity between western Canada and PADD 2. The resulting calculation in Exhibit 26 shows that only 2,028,000 barrels per day of the available 2,253,000 barrels per day of trading capacity will be utilized. Instead western Canada will trade 274,000 barrels per day of its excess supply to other regions.

IX. Conclusion and Results

The calculations throughout this paper help to understand the effect that the Keystone XL pipeline will have on various crude oil prices around North America. The model can be used to see the difference in regional crude prices for numerous situations. Exhibit 17 showed the changes in regional long-term crude prices around North America if the Keystone XL pipeline was constructed and this was the only policy change. This calculation showed an increase in both western Canadian crude oil price from $89.00/bbl to $106.00/bbl and the PADD 2 crude oil price from $97.00/bbl to $112.50/bbl only when both sections of the Keystone XL pipeline are built. This will result in the WTI price and Brent price of crude to be more equal, which is a major problem in the global crude market today. If the portion of the Keystone XL pipeline between western Canada and PADD 2 is not built only the PADD 2 price will rise from $97.00/bbl to $112.50/bbl, while the western Canada price will remain at $89.00/bbl. Therefore, the Keystone XL pipeline will help to solve a large problem in the crude oil market if only both sections are built. If only the Gulf Coast section is built then the price will only change in PADD 2. This entire pipeline will not only help the United States with a low crude oil price in the Midwest, but it will also greatly help Western Canada and the Canadian economy. Although this pipeline does not change the price for crude in PADD 3, it will help stabilize PADD 3 crude prices as more crude will be imported from PADD 2 and western Canada. PADD 3 will import less crude from the Atlantic Ocean, which will

help the American economy rely less on overseas crude imports from many middle-eastern countries.

This paper also demonstrates how to use this model to estimate changes in crude oil prices following many other policy or decision changes. As many of these policies have a large effect on the capacity of crude oil trade across North America, this model can be used to demonstrate the effects of these changes.

The main conclusion to draw from these calculations above are that the Keystone XL pipeline will be an effective method of reducing the current spread of western Canadian (WCS), WTI and Brent crude oil prices. It will do so by allowing crude oil to flow from western Canada to PADD 2 and also from PADD 2 to PADD 3. Also, the calculations show that the spread between WCS and Brent will only reduce if the entire Keystone XL pipeline is constructed. If only phase 3 is constructed than the spread between WCS and Brent will not be reduced and prices will stay the same as current. Although the WCS and Brent prices stay as is, the WTI and Brent prices will be come closer together as the WTI price raises. Therefore, this will not only bring positive changes for the crude oil market in the United States but will also positively affect the Canadian crude oil market and economy as well as long as the entire Keystone XL pipeline is constructed.

By assumption the price in PADD 3 will not change as it has access to the world market, but the construction of the Keystone XL pipeline will bring stability to the American economy by reducing imports from the Atlantic Ocean and OPEC countries to meet the large excess demand in PADD 3. As western Canadian crude oil production is expected to continually increase with the production from

Canadian Oil Sands, this Keystone XL pipeline will provide the extra capacity needed for the United States to utilize this increase in Canadian production, and strengthen the North American economy.

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