EVALUATING THE ECONOMIC IMPACTS OF PIPELINE USEAGE ON THE TEXAS OIL & GAS SUPPLY CHAIN

By

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Abstract

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The objective of this dissertation is to find the minimum supply chain cost for the Texas oil and gas industry, when pipeline is used as the major mode of transporting oil. The problem is solved, by introducing a mixed – integer linear programming model which will help in taking the necessary decisions based on the cost estimates for various scenarios. In order to meet the objective, specific objectives were put down to evaluate their impacts. First was to evaluate the economic impact of mode of transport and the infrastructure second was to evaluate the economic impact of refinery flow. Finally this dissertation aims at the mixed – integer programming model to demonstrate the economic impacts of pipeline usage on the supply chain.

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Chapter 1

Introduction

1.1 The dependency of Texas economy on oil & gas sector

The Federal Reserve Bank of Dallas's analysts claim that a 45% decrease in the oil price (From $100/Barrel to ~$55/Barrel) can reduce the payrolls of Texas by $125,000, even if everything else stays the same.

As every industry is dependent on oil in this era, the cost of oil can dramatically impact the performance of any industry. But if we are able to reduce the cost of oil production, we can keep every industry under control.

1.1.1 Problem Statement

The US EIA states that Texas produced 3,140,000 barrels of oil per day in 2014. Therefore the annual production of crude oil in 2014 was around 1,146,100,000 barrels – see Figure 1. The average cost of 'West Texas Intermediate' crude oil was $95 in 2014. So this turns out that $108,879,500,000 worth of crude oil was produced in Texas in 2014.

The cost of transportation decides a fraction of final price of a barrel of oil. It accounts for almost 10%-15% of the final price per barrel of oil. If we are able to reduce the costs in the transportation of oil, we will be able to save a significant amount of money that can be utilized somewhere else to make the Texas economy even stronger.

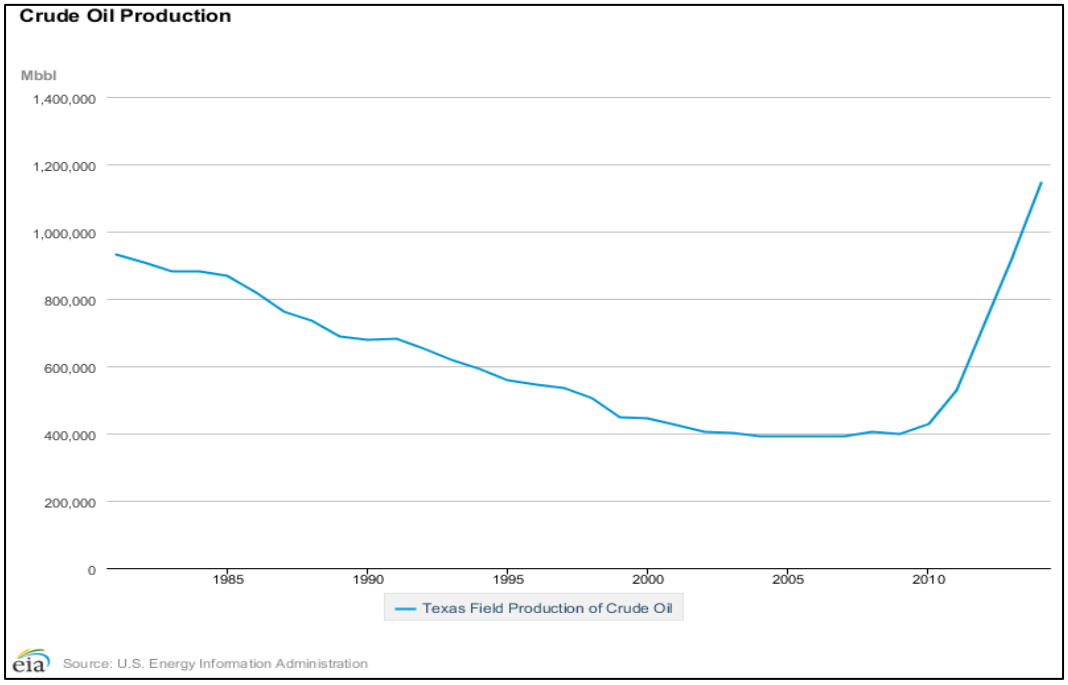

Figure 1 Texas Field Production of Crude Oil

1.1.2 Research Significance and broader impacts

There are several modes of transporting oil available today. But we have focused only on pipeline transportation as it is used in almost 70% of the cases. The objective of this research is to find whether the proportion at which the pipelines are used today to transport the oil is perfect for a business model or is their any flexibility for increasing the proportion of pipeline usage in oil transportation such that it results in overall cost reduction of oil per barrel.

This research introduces a Multi-Objective Linear Programming (LP) Model that represents Texas in such a way that it clusters the oil refineries in a particular area as one. After that, Pareto Analysis is used to identify the oil producing districts that contribute to almost 70% of total oil production in Texas. The oil producing districts are

selected with respect to the tradeoffs between the different proportions of pipeline being used from each oil producing districts and supply chain costs.

Furthermore, the broader impact of this research is that the transportation model of other states or even other countries can be quantified and optimized and compared to other modes of transporting oil.

1.1.3 Research Question and Hypotheses

The main motive of any industry is to get the product delivered to the customer at minimum costs and transportation being the important part of an oil supply chain, this dissertation strives to answer the question of “What proportion of pipeline should be used as the main source of transportation of oil from a particular oil production unit/district to a refinery?” This dissertation also hypothesizes that the proportion of pipeline used for the transportation of oil from an oil production unit to a refinery impacts the supply chain costs and ultimately defines the price of oil.

1.2 Research Purposes

Each organization in this world endeavors to augment its benefits and the shareholder esteem. Sorting out the creation can help any organization achieve this objective as it helps the organization to make benefit in the present time span and later on, expand the efficiency of the workers guaranteeing gainfulness and raise the organization's rate of return by making ventures. Each one of these exercises, when performed together, guarantee that the merchandise and administrations conveyed to the client are of most noteworthy quality and at least expenses.

1.2.1 Overall Research Objective

In oil industry, assets enhancement through overseeing investigation, creation, and improvement exercises will augment the shareholder worth to ensure a working business. Hence, substitution and the capacity to extend creation and deals to take care of demand are important to guarantee long haul practicality of the oil organizations. The proficiency in all parts of the store network prompts cost minimization, enhancements in item execution and ecological uprightness.

A lion's share of governments claim their national oil organizations, in this way the organizations don't take after the expansion of shareholder worth. Be that as it may, they may need to contend with other government's destinations so as to amplify the shareholder esteem. The measure of an administration's impact on its national oil organizations changes generally.

With the point of noting the examination question and diminishing the expense of transportation of oil, this paper has a general target to research a multi-objective Linear Programming (LP) model that backs choices about the right proportion of pipelines to transport oil to decrease the expense of transportation so it turns out to be more economical for Texas oil refineries.

1.2.2 Specific Research Objectives

Dissimilar to different countries, the US doesn't possess a national oil organization. On the off chance that the US possessed a national organization, it would be built up in light of a "non-advertise method" arrangement and would have some potential focal points that different organizations don't share, for example, acting to balance other national oil organizations like how other countries' national oil organizations act. Some potential drawbacks such that if the US had conflicts with a host

country, that nation may be all the more eager to evacuate the US national oil organization versus a privatized universal organization in light of the fact that global legislative issues assume a bigger part; and worldwide private oil organizations are by and large more proficient and beneficial, particularly as far as obtaining entrance to drilling regions.

The target of this dissertation is to assess the viability of a multi-objective linear programming (LP) model that exhibits the tradeoffs between the extents of pipeline utilized on the profits of refineries. So as to meet this target, a few particular goals are explored, for example, assessing the production network figures focus on the method of transportation of oil and assessing the monetary effects focus on utilizing diverse extents of pipelines to transport oil in Texas.

Chapter 2

Background

2.1 Crude oil

Unrefined petroleum or fluid petroleum is discovered aggregated in different permeable rock arrangements in Earth's covering and is extracted for using as fuel.

Unrefined petroleum is a blend of similarly unpredictable fluid hydrocarbons (mixes made basically out of hydrogen and carbon), however it likewise contains some nitrogen, sulfur, and oxygen. Those components frame a huge mixture of complex atomic structures, some of which can't be promptly recognized. Notwithstanding varieties, on the other hand, all unrefined petroleum ranges from 82 to 87 percent carbon by weight and 12 to 15 percent hydrogen by weight.

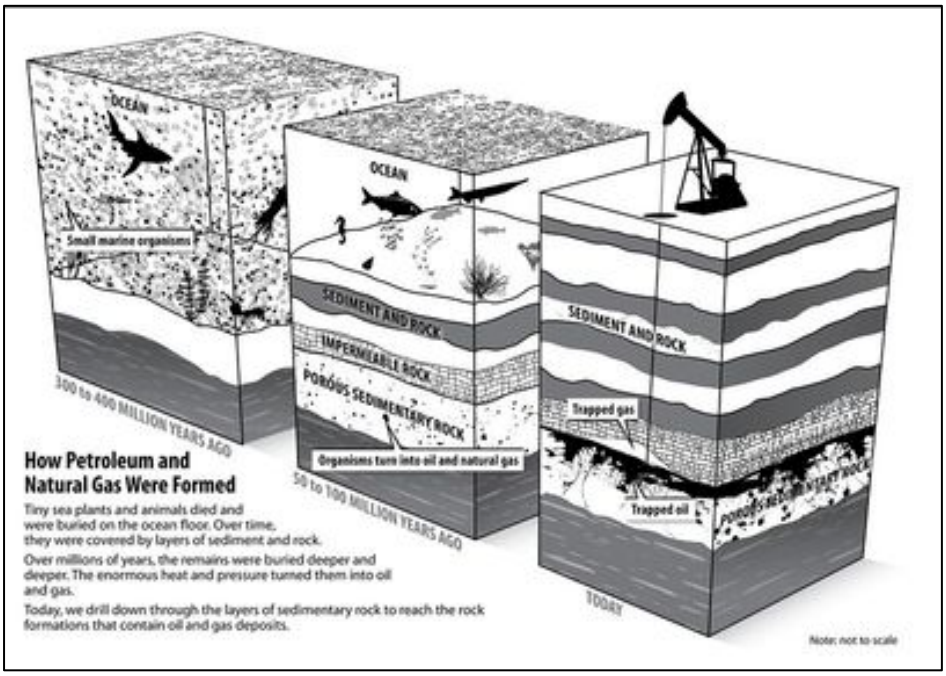

Figure 2 Crude Oil Formation

The sort of hydrocarbon that is most predominant in them generally describes unrefined oils: paraffins, naphthenics, and aromatics. Paraffins are the most well known hydrocarbons in unrefined petroleum; certain fluid paraffins are the significant constituents of gas (petrol) and are accordingly exceedingly valued. Naphthenes are an essential piece of all fluid refinery items, however they likewise shape a percentage of the substantial asphaltlike buildups of refinery procedures. Aromatics for the most part constitute just a little ratio of most crudes. The most widely recognized fragrant in unrefined petroleum is isobenzene, a well known building piece in the petrochemical business.

Since unrefined petroleum is a blend of such generally shifting constituents and extents, its physical properties likewise fluctuate broadly. In appearance, for case, it runs from clear to dark. Conceivably the most critical physical property is specific gravity (i.e., the proportion of the heaviness of equivalent volumes of a raw petroleum and unadulterated water at standard conditions). In research center estimation of specific gravity, it is standard to give away clear water an estimation of 1; substances lighter than water, for example, raw petroleum, would get estimations under 1. The petroleum business, notwithstanding, uses the American Petroleum Institute (API) gravity scale, in which clear water has been discretionarily appointed an API gravity of 10°. Fluids lighter than water, for example, oil, have API gravities numerically more prominent than 10. On the basis of their API gravity, unrefined oils can be named heavy, medium, and light as takes after:

- Heavy: 10–20° API gravity
- Medium: 20–25° API gravity
- Light: over 25° API gravity

Raw petroleum additionally is considered as "sweet" or "sour" contingent upon the level of sulfur, which happens either as basic sulfur or in mixes, for example, hydrogen sulfide. Sweet crudes have sulfur substance of 0.5 percent or less by weight, and sharp crudes have sulfur substance of 1 percent or all the more by weight. By and large, the heavier the unrefined petroleum, the more noteworthy is its sulfur content. Overabundance sulfur is expelled from raw petroleum during refining, in light of the fact that sulfur oxides discharged into the climate during burning of oil are a noteworthy poison.

In the United States, the customary practice for the petroleum business is to quantify limit by volume. Thus, unrefined petroleum in the United States is measured in barrels, every barrel contains 42 gallons of oil. Most different zones of the world characterize limit by the heaviness of materials handled and record estimations in metric units; in this manner, raw petroleum outside the United States is normally measured in metric tons. A barrel of API 30° light oil would weigh around 139 kg (306 pounds). On the other hand, a metric ton of API 30° light oil would be equivalent to more or less 252 supreme gallons, or around 7.2 U.S. barrels.

Unrefined petroleum happens underground, at different weights relying upon profundity. It can contain significant regular gas, kept in arrangement by the weight. What's more, water frequently streams into an oil well alongside fluid unrefined and gas. Every one of these liquids is gathered by surface gear for partition. Clean unrefined petroleum is sent to capacity at close barometrical weight, generally over-the-ground in tube shaped steel tanks that may be as substantial as 30 meters (100 feet) in distance across and 10 meters (33 feet) tall. Regularly unrefined petroleum must be transported from broadly appropriated creation locales to treatment plants and refineries. Overland development is to a great extent through pipelines. Unrefined from more detached wells

is gathered in tank trucks and taken to pipeline terminals; there is additionally some vehicle in extraordinarily developed railroad zones. Abroad transport is directed in exceptionally composed tanker boats. Tanker limits differ from under 100,000 barrels to more than 3,000,000 barrels.

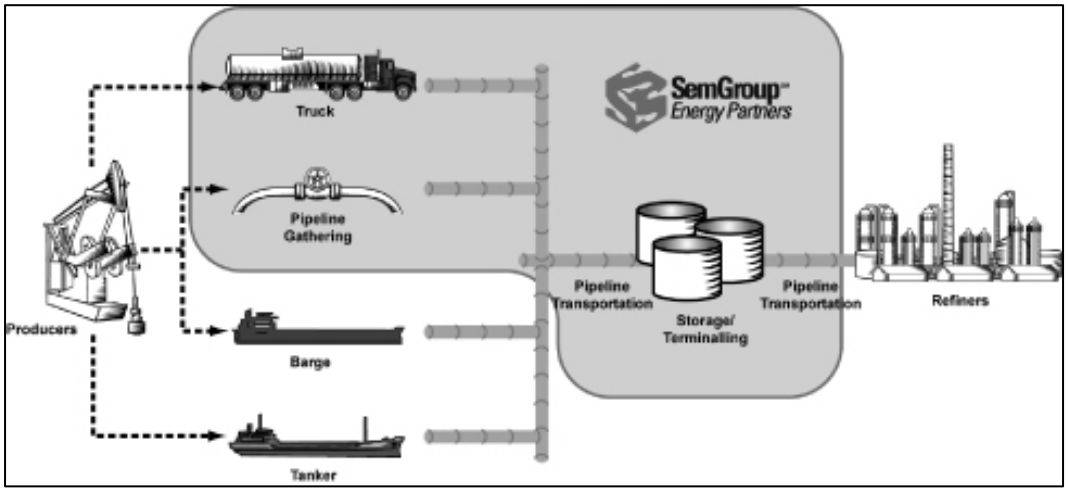

Figure 3 Crude Oil Transportation

The essential destination of raw petroleum is a refinery. There any mix of three fundamental capacities is completed: (1) isolating the numerous sorts of hydrocarbon present in rough oils into parts of all the more firmly related properties, (2) synthetically changing over the isolated hydrocarbons into more attractive response items, and (3) cleaning the results of undesirable components and mixes. The primary procedure for isolating the hydrocarbon parts of unrefined petroleum is fractional distillation. Raw petroleum divisions isolated by refining are gone on for consequent preparing into various items, running from fuel and diesel to warming oil to black-tar. Given the example of current interest (which has a tendency to be most astounding for transportation energizes, for example, gas), the business sector estimation of unrefined petroleum by and large ascents with expanding yields of light items.

Petroleum is a normally happening hydrocarbon material that is accepted to have shaped from creature and vegetable remains in profound sedimentary beds. The petroleum, being less thick than the surrounding water, is removed from the source overnight pumping upward through permeable rocks, for example, sandstone and some limestone until it is at last hindered by nonporous rocks, for example, shale or thick limestone. Along these lines, petroleum stores came to be caught by geologic elements brought on by the collapsing, crushing, and disintegration of the Earth's outside layer.

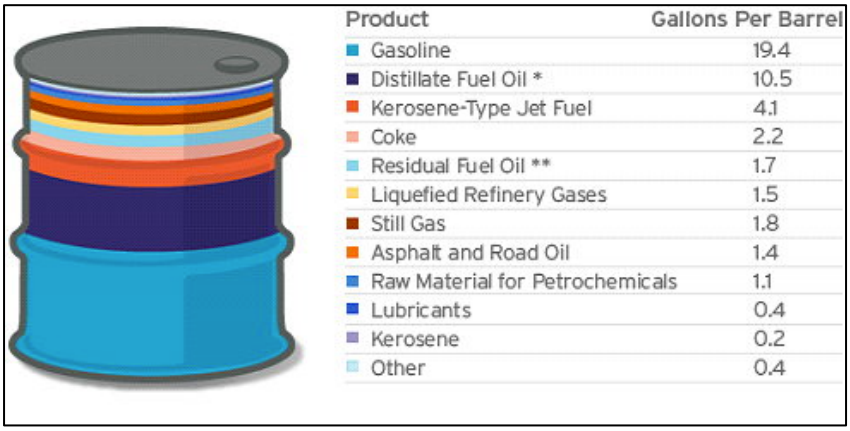

Figure 4 Crude Oil Composition

Petroleum may exist in vaporous, fluid, or close strong stages either alone or in blend. The fluid stage is generally called unrefined petroleum, while the more strong stage may be called bitumen, tar, pitch, or coke. At the point when these stages happen together, gas as a rule overlies the fluid, and the fluid overlies the more strong stage. Periodically, petroleum stores hoisted amid the arrangement of mountain reaches have been presented by disintegration to frame tar stores. Some of these stores have been known and abused all through written history. Other close surface stores of fluid petroleum leak gradually to the surface through regular crevices in the overlying rock. Collections from these leaks, called rock oil, were utilized monetarily as a part of the

nineteenth century to make light oil by basic refining. The lion's share of petroleum stores, be that as it may, lie caught in the pores of regular rock at depth from 150 to 7,600 meters (500 to 25,000 feet) beneath the surface of the ground. The more deep stores have higher inner weights and contain more prominent amounts of vaporous hydrocarbons.

When it was found in the nineteenth century that stone oil would yield a refined item (lamp oil) suitable for lights, new wellsprings of this mineral were willingly looked for. It is presently for the most part concurred that the first all around penetrated well particularly to discover oil was that of Edwin Laurentine Drake in Titusville, Pa., U.S., in 1859. The accomplishment of this very much, penetrated near to an oil leak, incited further boring in the same region and soon prompted comparative investigation somewhere else. Before the century was over, the developing interest for petroleum items brought about the boring of oil wells in different states and nations. In 1900, unrefined petroleum generation worldwide was about 150 million barrels. A large portion of this aggregate was delivered in Russia, and most (80 percent) of the rest was created in the United States.

The development of car use in the second decade of the twentieth century made an incredible interest for petroleum items. Yearly production surpassed one billion barrels in 1925 and two billion barrels in 1940. By the most recent decade of the twentieth century, there were very nearly one million wells in more than 100 nations creating more than 20 billion barrels for every year. Petroleum is delivered in every landmass with the exception of Antarctica.

2.2 Crude Oil Extraction

Fracking additionally spelled fracing or fraccing, likewise called hydrofracking, in full hydraulic cracking, is common in gas and petroleum generation. It is the infusion of a fluidant of high weight into an underground crack development with a specific end goal to open crevices and permit caught gas or raw petroleum to move through a pipe to a wellhead at the surface. It is utilized in blend with enhanced strategies for penetrating on a level plane through rock layers, and water driven cracking has opened up inconceivable natural gas stores in the United States. In the short time, the quick increase of the practice, oftentimes in areas with no history of concentrated oil and gas penetrating, has raised concerns over its monetary and natural outcomes.

The innovation of pressure driven cracking has been used following the 1940s, when fluids, for example, gas and raw petroleum were infused into ineffectively performing gas and oil wells in the southern United States with the point of expanding their stream rate.

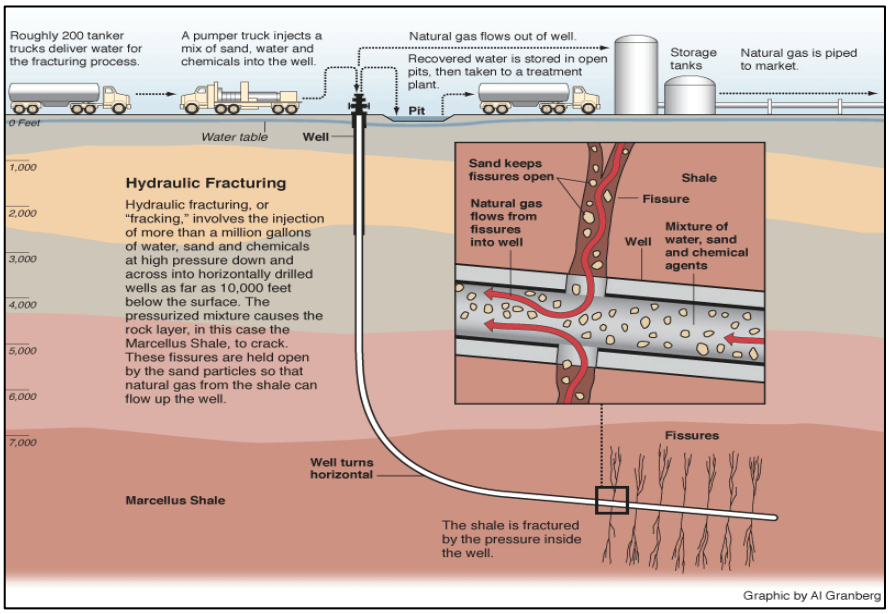

Figure 5 Hydraulic Fracking

Over the next decades, procedures were enhanced—for example, treated water became the favored cracking medium, and finely evaluated sand or manufactured materials were received as a "proppant" to hold open the cracks. On the other hand, fracking did not enter its present current stage until the 1990s, when the utilization of new steerable boring apparatus engines and electronic telemetering gear permitted administrators to coordinate borehole boring and screen the cracking procedure with extraordinary effectiveness.

Gas from unconventional stores incorporates coal bed methane (gas situated in the joints and breaks of coal creases), "tight gas" (gas bolted into generally impermeable sandstone or limestone arrangements), and shale (gas consolidated into thick microporous shales). Fracking has been utilized to recover every one of these gas sorts.

Most gas shales are found in broad creases hundreds or a great many meters underneath the surface. These creases can be gotten to through routine vertical drilling, yet the most profitable system is generally flat penetrating. In this procedure a well is started in the conventional path, with the forecasting of a pilot gap typically by most accounts 6 to 15 meters (20 to 50 feet) profound. This is lined with a steel pipe in the ballpark of 40 to 50 cm (16 to 20 inches) in distance across, called the conductor casing, which is established into spot. From that point the borehole is bored straight down, going through various rock layers that may incorporate freshwater aquifers utilized for private wells or city water supply. This part of the borehole is lined with an established steel funnel called the surface casing. Contingent upon generation needs or natural regulations, another funnel, called the middle casing, may be established inside the surface casing.

At a predetermined "kickoff point" (now and again over the shale arrangement, in different cases inside of it), a steerable boring tool is introduced, and the borehole is

swung to the flat. From that point penetrating proceeds inside of the shale, now and again for another thousand meters or more. At the point when this sidelong area of the well is penetrated, the whole borehole is lined with yet another funnel called the generation casing. In numerous operations more than one well can be penetrated from an isolated surface site (or "cushion"), or more than one horizontal area can transmit from an isolated borehole.

When penetrating and packaging are finished, the generation casing down the borehole is punctured by an instrument that flames a progression of little, pointed unstable charges through the mass of the channel. At the surface, the penetrating apparatus is evacuated, and the fracking procedure starts. Normally, a number of tanker trucks merge on the cushion alongside a few trailer-mounted water powered pumpers, blenders, and compound stockpiling tanks, an independent control vehicle or trailer stuffed with gadgets, and other gear.

The measure of crisp water utilized as a part of fracking a solitary shale gas well differs incredibly, contingent upon the span of the well and the measure of cracking that must be done to discharge the gas: business and administrative sources give assumes that range from more or less 7.5 million to 20 million liters (2 million to 5 million gallons)—generally equal to the water contained in three to eight Olympic-size swimming pools. Ecological gatherings contend that, in new territories where fracking may become significant, such utilization may speak to an unsustainable utilization of the area's crisp water. Accordingly, the shale gas industry demands that breaking for shale gas devours less water per unit than is utilized as a part of coal and even routine oil creation. The water is acquired from sources controlled by the business sector and regulations—e.g., obtained from the city water supply, pumped from neighborhood waterways or streams, reused from past frack occupations. Once in a while it is channeled straightforwardly to

the shale, and frequently it is put away there in steel tanks or in extensive, shallow lakes that have been exhumed out of the ground and lined with plastic.

Utilizing new water, a blend of fluid and proppant is mixed that comprises of in the range of 90 percent water, under 10 percent sand, and 0.5–2 percent concoction added substances; these last incorporate gelling specialists, borehole-cleaning acids, erosion anticipating stabilizers, and petroleum-based rubbing reducers—all consolidated to create a "slickwater" judged to be ideal for the specific employment. The exact equations for these cracking liquids are all around monitored organization insider facts, however the sorts of substance mixes utilized are generally known.

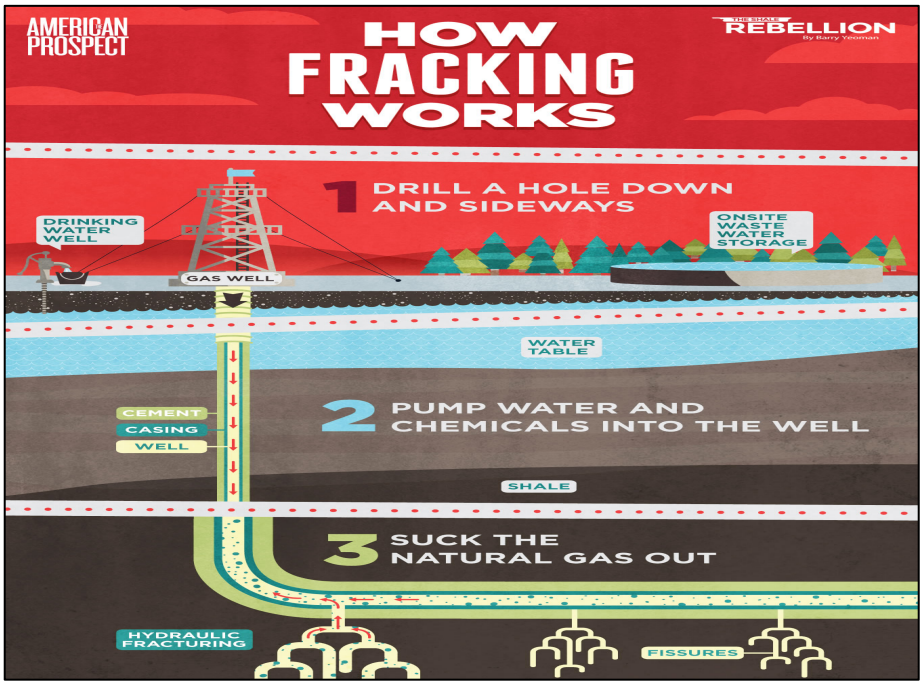

Figure 6 How Fracking Works

In a progression of firmly observed operations, the liquid is pumped down the borehole and through the apertures in the foundation casing under extraordinary weight, sufficiently capable to grow and prop open existing minor crevices in the shale. When

breaking is finished, foundation tubing is embedded into the well. Gas liberated from the cracked rock enters the tubing and streams to the surface, where a system of valves at the wellhead called the "Christmas tree" replaces the fracking gear. Fracking liquid returns alongside the gas and sometimes-saline solutions from the shale arrangement. These fluids are occupied to the settling lakes or tanks for further treatment and transfer. A completed foundation site in the end may be stripped of all past hardware and structures, leaving minimal more than the Christmas tree (or trees), associations with a gas pipeline, tanks for putting away dense fluids, and backing and support gear. Unused settling lakes are filled in.

2.3 Crude Oil in Texas

For Texans, the twentieth century did not start on January 1, 1901, as it accomplished for others. It started nine days after the fact, on Jan. 10, when, spurting penetrating channel, mud, gas and oil, the Lucas No. 1 well blew in at Spindletop close Beaumont.

The gusher released oil more than 100 feet into the air until it was topped nine days after the fact. With that sensational flourish, Texas' economy was twisted from its rustic, agrarian roots and flung headlong into the petroleum and mechanical age.

Figure 7 Spindletop

In the most recent years of the nineteenth century, railways had rolled out clearing improvements in the lives of a significant number of Texas' for the most part country, for the most part agrarian nationals changed the substance of the state. Settlements conformed to brief railroad-specialists' camps. Theorists made fresh out of the box new towns out of prairie next to the sparkling rails.

At the point when oil came spouting into Texas right on time in the twentieth century, the progressions were considerably more significant. Petroleum started to uproot farming as the foremost drivers of the economy of the state, and Texans' lives were much more definitely influenced than they had been by railways.

The effect of oil on Texas and Texans is frequently broke down regarding corporate improvement, individual and corporate riches, and the general economy of the state and legislative issues. Oil additionally significantly influenced the lives of the individuals who claimed the area from which oil was created, or who were specifically included in oil investigation, extraction and handling. The revelations of oil fields prompted the establishing and prospering of various Texas towns, to the foundation of organizations that have get to be multinational aggregates, and to the storing up of immeasurable individual fortunes.

On the other hand, the playing out of pumped-out oil fields prompted the passing of any number of those once-thriving towns.

In any case, Texas oil has influenced the lives of a huge number of Texans not straightforwardly included in the oil business – Texans who get neither a paycheck nor a sovereignty check in view of petroleum. Oil has significantly changed the way of life of the state, and it keeps on influencing most Texans' lives in ways that may not be clear to the easygoing spectators.

Chronological Listing of Major Oil Discoveries

The following list gives the name of the field, county and discovery date. Sources include Texas Mid-Continent Oil and Gas Association from records of the U.S. Bureau of Mines; the Oil and Gas Journal; previous Texas Almanacs, the New Handbook of Texas, and the Energy Information Administration of the U.S. Department of Energy.

FIELD	COUNTY	Year
Corsicana	Navarro	1894
Powell	Navarro	1900
Spindletop	Jefferson	1901
Sour Lake	Hardin	1902
Batson-Old	Hardin	1903
Humble	Harris	1905
Mission	Bexar	1907
Piedras Pintas	Duval	1907
Goose Creek	Harris	1908
Panhandle Osborne	Wheeler	1910
Archer County	Archer	1911
Electra	Wichita	1911
Burk	Wichita	1912
Iowa Park	Wichita	1913
Orange	Orange	1913
Somerset	Bexar	1913
Damon Mound	Brazoria	1915
Thrall	Williamson	1915

FIELD	COUNTY	Year
Sugarland	Fort Bend	1928
Darst Creek	Guadalupe	1929
Penwell	Ector	1929
Pettus	Bee	1929
Van	Van Zandt	1929
Cowden North	Ector	1930
East Texas	Cherokee-Gregg-Rusk-Smith-Upshur	1930
Fuhrman-Mascho	Andrews	1930
Sand Hills	Crane	1930
Conroe	Montgomery	1931
Manvel	Brazoria	1931
Tomball	Harris	1933
Dickinson	Galveston	1934
Hastings East	Brazoria	1934
Means	Andrews	1934
Old Ocean	Brazoria	1934
Tom O'Connor	Refugio	1934

Figure 8 Oil Discoveries in Texas

2.3.1 Early Oil Discoveries

The vicinity of regular oil leaks in Texas had been known for many years before Europeans touched base in the territory. Indians in Texas are said to have told European pilgrims that the substance had restorative employments. In July 1543, the leftovers of Spanish adventurer Hernando de Soto's endeavor, drove by Luis de Moscoso Alvarado, were constrained shoreward along the Texas drift between Sabine Pass and High Island. Moscoso reported that the gathering discovered oil coasting on the surface of the water and utilized it to caulk their watercrafts.

Lyne T. Barret bored Texas' first creating oil well in 1866 at Melrose in Nacogdoches County. The next year, Amory Reily Starr and Peyton F. Edwards got a well at close-by Oil Springs. Different wells took after, making Nacogdoches County the site of Texas' first business oil field, first pipeline and first push to refine rough. A few thousand barrels of oil were created, yet the cost of oil was not sufficiently high to legitimize further endeavors at improvement. While boring for water in 1886, Bexar

County farmer George Dullnig discovered a little amount of oil, yet he didn't endeavor business generation.

City teams in Corsicana were additionally penetrating for water in 1894, when they made the first monetarily critical oil revelation in Texas. That well was surrendered on the grounds that the drillers expected to discover water, not oil. In any case, a few creating oil wells were bored in 1895 by Joseph S. Cullinan, who later helped discovered the Texas Company, which got to be Texaco. The primary all around prepared refinery in Texas was constructed at this field, and regardless of the early endeavors at Nacogdoches, it is typically called Texas' first refinery.

2.3.1.1 Spindletop

The oil revelation that jolted Texas' change into a noteworthy petroleum maker and modern force was Spindletop. Investigation in the territory of the upper Gulf Coast close Beaumont had started in 1892. In the wake of penetrating a few dry gaps, Louisiana mining specialist and oil miner Capt. Anthony F. Lucas penetrated the revelation well of the Spindletop field. At first, the Lucas No. 1 created more than an expected 75,000 barrels of oil a day. Top yearly generation was 17.5 million barrels in 1902.

Spindletop, which was likewise the first salt-vault oil disclosure, set off a surge of hypothesis in the territory, bringing about a few other huge revelations. The blast incorporated a convergence of several excited wildcatters – including previous Governor James Stephen Hogg – pining for a share of any profits, and in addition a large number of laborers searching for occupations. Directly behind them came a tsunami of related administration, supply and assembling firms, for example, refineries, pipelines and oil-field gear producers and merchants. It was California's mythical Gold Rush of 50 years

prior rehashed on the Texas Gulf Coast with rotational boring tools and derricks rather than pick tomahawks and gold container.

Organizations were soon settled to add to the Gulf Coast oil fields. A large portion of them turned into the business goliaths of today: Gulf Oil; Sun Oil Company; Magnolia Petroleum Company; the Texas Company; and Humble Oil, which later partnered with Standard Oil of New Jersey and got to be Esso, then today's Exxon. Refineries, pipelines and fare offices turned into the core of the major modern locale that started to frame along the Texas drift around Port Arthur and Beaumont. The New Handbook of Texas abridges the impact of Spindletop along these lines: "The disclosure of the Spindletop oil field had a practically boundless impact on world history, and additionally Texas history. Avid to discover comparable stores, speculators burned through billions of dollars all through the Lone Star State looking for oil and regular gas. The modest fuel they discovered served to upset American transportation and industry."

Texas oil generation was 836,039 barrels in 1900. In 1902, Spindletop alone delivered more than 17 million barrels, or 94 percent of the state's generation. As an aftereffect of the overabundance, oil costs dropped to an untouched low of 3 pennies a barrel, while water in some blast towns sold for 5 pennies a container.

2.3.1.2 Oil in North Texas

Somewhere around 1902 and 1910, oil fever spread through North Central Texas, with finds at Brownwood, Petrolia and Wichita Falls.

Water-well drillers on the W.T. Waggoner Ranch in Wichita County in 1911 discovered oil rather, making the Electra field. In 1917, W.K. Gordon, general supervisor of the T&P Coal Company's mines at Thurber, found the Ranger field close-by. Incidentally, the abundance of oil at Ranger, and somewhere else in the state, urged

railways to change their trains from coal to oil and helped murder the coal-mining town of Thurber.

Oil was discovered west of Burkburnett in Wichita County in 1912, trailed by another oil field in the town itself in 1918. The hot action that took after propelled the 1940 motion picture Boom Town, featuring Clark Gable, Spencer Tracy, Claudette Colbert and Hedy Lamarr.

The blast town marvel got to be basic over the state: The frameworks of little cultivating groups close oil revelations were deficient to the requests of the populace blasts. They hadn't adequate cabin or eating foundations for the sudden inundation. Newcomers were compelled to live in hurriedly raised shacks, tents or even their autos or trucks. Since some of those attracted to oil fields by longs for wealth brought their families, schools got to be stuffed. There were lines at bistros, at mail station counters, all over.

Out of the blue substantial movement on the regularly unpaved roads made gigantic dust storms amid dry climate – dust that attacked each corner and settled on every surface. In wet climate, the boulevards got to be vehicle-gulping mudholes.

Amid the 1920s, there were disclosures close Mexia in Limestone County and all the more in Navarro County. Oil was found in the Panhandle beginning in 1921, and real fields were produced all over the state amid the following decade – East Texas, west-focal Texas and extra fields in the Gulf Coast.

2.3.1.3 East Texas

In October 1930, the Daisy Bradford No. 3 well blew in close Turnertown and Joinerville in Rusk County, opening the East Texas field, the greatest field of all. Veteran wildcatter C.M. (Father) Joiner penetrated the well ashore since quite a while ago

rejected by significant organizations' geologists as not deserving of their endeavors. The greatest renting crusade in history resulted, and the movement spread to incorporate Kilgore, Longview and numerous focuses north. Overproduction soon took after, as oil derricks grew thick as bamboo everywhere throughout the field. With no well-dispersing regulations and no restrictions on creation, the cost of oil plunged once more.

On Aug. 17, 1931, Gov. Ross S. Sterling requested the National Guard into the East Texas field, which he put under military law. This exceptional move was made after the Texas Railroad Commission had been charged from implementing creation confinements. After over two years of fights in court, most East Texas administrators acknowledged customization, the arrangement of regulation still used.

When the East Texas field was produced, Texas' economy was controlled not by horticulture, but rather by petroleum.

- Oil's Ripple Effects

Step by step, the oil excess started to influence common Texans. Not long after Spindletop, the accessibility of a sea of shoddy oil empowered its utilization as fuel for transportation and assembling. After railways changed over from coal to oil, steamships took after, drove by those working in the Gulf of Mexico and the Caribbean.

As autos turned out to be more normal, streets started to be cleared over the state.

Automation of ranch work expanded rapidly, empowering agriculturists to create more sustenance with fewer individuals. Assembling plants grew in the once in the past horticultural state, utilizing shoddy oil as fuel. Texas' populace scales, intensely weighted toward the rustic before Spindletop, began to adjust, and by 1940, the populace was even: 55 percent provincial and 45 percent urban. World War II tipped the scales, be that as it may, when wartime occupations at assembling plants in the urban areas attracted

expansive quantities of individuals from homesteads and residential areas. Most stayed away forever.

This dislodging of cultivating families was exacerbated by the assimilation of numerous family cultivates into substantial corporate operations. Expanding quantities of transients from different states and outside nations likewise settled essentially in urban focuses. By 1980, the state was four-fifths urban.

As of Jan. 1, 1997, State Data Center populace assessments demonstrate that of the state's populace (19,598,471), more than 33% was amassed in the three biggest provinces: Harris (3,178,995), Dallas (2,032,171) and Bexar (1,342,934).

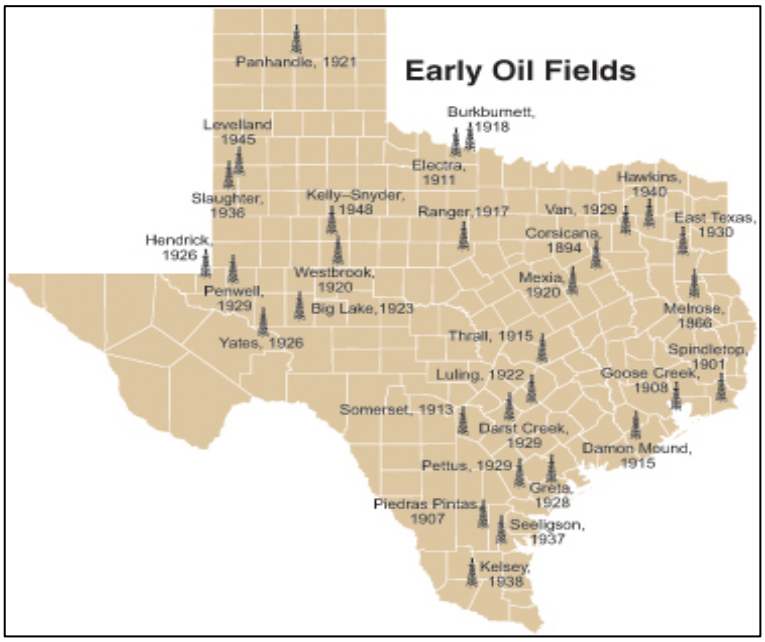

Figure 9 Early Oil Fields in Texas

- State Government Tax on Oil Production

Another change realized by the disclosure of oil was the enhancement of the state treasury after the council approved an oil-creation imposes in 1905. The principal

entire year the duty was gathered, general society coffers swelled by $101,403. By 1919, the income from the oil-generation expense was more than $1 million; by 1929, it was very nearly $6 million. In 1996, the most recent year for which we had figures at press time, it was barely shy of $376 million for the financial year.

Oil and regular gas are the most important minerals delivered in Texas. They have been created from most ranges of Texas and from rocks of every single geologic period aside from the Precambrian. The majority of the major sedimentary bowls of Texas have created some oil or gas.

The Permian Basin of West Texas has yielded huge amounts of oil subsequent to the Big Lake disclosure in 1923, albeit there was a littler revelation in the Westbrook field in Mitchell County three years prior.

The 1923 revelation, Santa Rita No. 1 in Reagan County, was on University of Texas area, and it and Texas A&M University both have profited from the sovereignties.

Albeit expansive amounts of petroleum have been delivered from rocks of Permian age, generation in the range additionally happens from more established Paleozoic rocks. Creation from rocks of Paleozoic age happens principally from North Central Texas westbound to New Mexico and southwestward to the Rio Grande, however there is additionally noteworthy Paleozoic generation in North Texas.

Mesozoic rocks are the essential hydrocarbon repositories of the East Texas Basin and the region south and east of the Balcones Fault Zone. Cenozoic sandstones are the principle stores along the Gulf Coast and seaward state waters.

- Earliest Oil

Indians discovered oil leaking from the dirts of Texas much sooner than the first Europeans arrived. They told adventurers that the liquid had therapeutic qualities. The primary record of Europeans utilizing unrefined petroleum, in any case, was for the

caulking of watercrafts in 1543 by survivors of the DeSoto undertaking close Sabine Pass.

Melrose, in Nacogdoches County, was the site in 1866 of the initially bored well to deliver oil in Texas. The driller was Lyne T. Barret. Barret utilized a wood screw, attached to a channel, and turned by a cogwheel driven by a steam motor — a fundamental standard of revolving penetrating that has been utilized subsequent to, in spite of the fact that with much change.

In 1867, in the same range, Amory (Emory) Starr and Peyton F. Edwards acquired a well at Oil Springs.

Different wells took after, and Nacogdoches County was the site of Texas' first business oil field, pipeline, and push to refine rough. A few thousand barrels of oil were created there amid these years.

- Initially significant refinery, 1899

Other oil was found in roughly delved wells in Bexar County in 1889 and in Hardin County in 1893. The three little wells in Hardin County prompted the making of two little refineries in 1896 and 1898.

Yet, it was not until June 9, 1894, that Texas had a noteworthy revelation. This happened in the boring of a water well for the city of Corsicana. Oil brought on that well to be relinquished, however an organization shaped in 1895 penetrated a few creating oil wells.

The main all around prepared refinery in Texas was implicit Corsicana in 1898, and this plant, which delivered its first generation in 1899, ordinarily is known as the state's first refinery, regardless of the prior endeavors. Disclosure of the Powell Field, additionally close Corsicana, followed in 1900.

- Spindletop, 1901

Jan. 10, 1901, is the most well known date in Texas petroleum history. This is the date that the colossal gusher ejected in the oil prosperity bored at Spindletop, close Beaumont, by a mining architect, Capt. A. F. Lucas.

This was the first salt arch oil disclosure, and a huge number of barrels of oil streamed before the well could be topped. Spindletop drummed up some excitement all through the world and energized investigation and penetrating in Texas that has proceeded following.

Texas oil creation expanded from 836,039 barrels in 1900 to 4,393,658 in 1901; and in 1902 Spindletop alone delivered 17,421,000 barrels, or 94 percent of the state's generation. Costs dropped to 3 pennies a barrel, an unequaled low.

- Seaward, 1908

The principal seaward penetrating was in shallow northern Galveston Bay, where the Goose Creek Field was found in 1908. A few dry openings took after, and the field was surrendered. In any case, a gusher in 1916 made the genuine blast there.

- 1911–1929

In 1911, a water-well penetrating outfit on the W. T. Waggoner Ranch in Wichita County hit oil, getting the Electra Field. Salt vault oil fields took after at Damon Mound in 1915 (Brazoria County), Barbers Hill in 1916 (Chambers County), and Blue Ridge in 1919 (Fort Bend County).

In 1917, came the disclosure of the Ranger Field in Eastland County. The Burkburnett Townsite Field in Wichita County was found in 1918.

About this time, oil disclosures got a short period of cheating, with oil stock advancement and offering on an across the country scale. It finished after a progression of trials in government courts, however the oil disclosures proceeded. The Mexia Field in

Limestone County was found in 1920, and the second Powell Field in Navarro County in 1924.

Another extraordinary region grew in 1921 in the Panhandle, with thrilling oil and gas disclosures in Hutchinson and bordering areas and the blasting of the town of Borger.

The Luling Field in Caldwell County open in 1922, and 1925 saw the rebound of Spindletop with a generation bigger than that of the first field.

In 1925, Howard County was opened for generation. Hendricks in Winkler County opened in 1926, and Raccoon Bend, Austin County, opened in 1927. Sugar Land was the most critical Texas oil advancement in 1928.

The Darst Creek Field in Guadalupe County was opened in 1929. Around the same time, new records of beneficial sand thickness were situated for the business at Van, Van Zandt County. Pettus in Bee County was another commitment to the 1929 revelations.

- East Texas Field

The East Texas field, greatest of every one of them, was found close Turnertown and Joinerville, Rusk County, by veteran wildcatter C. M. (Father) Joiner in October 1930. The achievement of this well — bored ashore denounced ordinarily by geologists of the real organizations — was trailed by the greatest renting battle ever.

The field soon was reached out to Kilgore, Longview, and northward. The East Texas field brought overproduction and a fast sinking of the cost. Private endeavors were made to customize generation, however without much achievement.

On Aug. 17, 1931, Gov. Ross S. Sterling requested the National Guard into the field, which he set under military law. This extraordinary move was made after the Texas Railroad Commission had been ordered from upholding creation confinements. After the

complete shutdown, the Texas Legislature established lawful customization, the arrangement of regulation still used.

- West Texas

The most critical consequent oil revelations in Texas were those in West Texas. In 1936, oil was found west of Lubbock in the Duggan Field in Cochran County.

Initially Duggan was thought to be one of two fields, it and the nearby Slaughter Field, yet in 1940 the Railroad Commission decided that the two created from one supply and called both ranges Slaughter. The productive Levelland Field, in Cochran and Hockley areas, was found in 1945. A disclosure well in Scurry County on Nov. 21, 1948, was the first of a few noteworthy advancements in that district. Huge numbers of the main Texas districts in minerals worth are in that locale.

- Austin Chalk

The Giddings Field on the Austin Chalk in Lee, Fayette, and Burleson regions had huge boring in the 1970s that proceeded into the 1980s.

2.4 Texas Economy and Crude Oil

Presently America's second-most crowded state, Texas has a Spain-sized economy more prominent than $1.5 trillion, speaking to around one-tenth of national yield. From 2009 to 2013, Texas delighted in a vigorous development rate of 4.4 percent a year, about double the national normal. Sheryl Jean of The Dallas Morning News figures that since 2009 Texas has made almost one out of each four employments across the country.

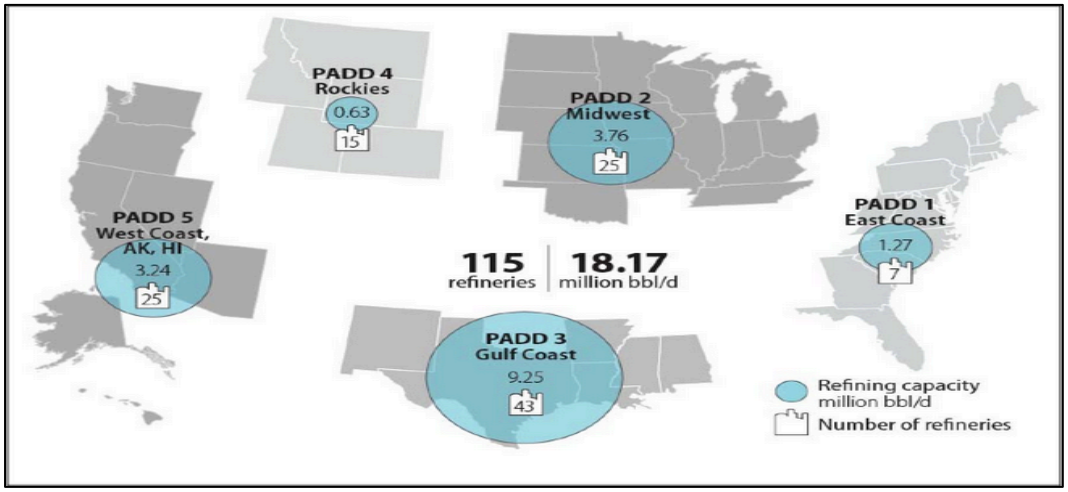

Figure 10 PADD Distribution

There is no doubt that the noteworthy "fracking" insurgency in shale oil and characteristic gas creation has turbocharged the state's economy. Texas, which creates more than 33% of the country's oil, has seen its oil generation twofold in three years. Oil and gas today speak to around 11 percent of aggregate monetary yield in Texas, the same as it was in the mid-1980s.

These are stressing numbers to anybody acquainted with the blast and-bust cycles of the oil and gas industry. Like Depression-time Americans, Texans are spooky by the agonizing recollections of the mid-80s when the oil patch became scarce. The inadvertent blow-back was massive. In those years, more than 700 Texas banks became penniless, and home costs in Texas fell 14 percent from their top. The outcome was boundless joblessness, void condo structures and rotting rural areas.

Truth be told, a Lone Star lull is as of now here. The Federal Reserve Bank of Dallas discharged an overview of Texas organizations this week demonstrating a drop when all is said in done business action.

Obviously, it would be a preeminent incongruity if the enhancing economy that President Barack Obama boasted about in his State of the Union were all of a sudden hurled once again into the soup by a definitive red state retreat. Be that as it may, before we begin stocking up on hamburger jerky and ammo, I see six reasons why the country's questionable national recuperation won't be dragged around a Texas subsidence.

To begin with, there is a whole other world to oil than "upstream" investigation and creation. The "downstream" refinery portion "breaks" hydrocarbons into the energizes, lubes, plastics and different synthetics that are the crude materials of assembling. Also, for the downstream, the less expensive and more plenteous the assets – whether they are from the Eagle Ford Formation in Texas or the tremendous stores of the Canadian oil sands – the fatter the edge. The Gulf Coast is hence creating the reasonable material premise for what numerous call an American fabricating Renaissance.

Second, Texas today has an exceedingly broadened information economy. The state's solid 3.6 percent business build a year ago saw the most employments added to expert classes, from modelers to IT. The slopes above Austin are dabbed with Silicon new companies. Houston is the undisputed vitality capital of the world, offering its aptitude from Brazil to Central Asia. Home to the world's biggest restorative complex, Houston is additionally celebrated as a worldwide focus of medicinal learning.

Third, the state's 27 million purchasers are profiting from the informal salary increase of shabby fuel, much the same as other people. Agribusiness is particularly profiting, with farmers grinning at their low fuel bills and ranchers saving money on everything from diesel to compost.

Fourth, Texas banks, blazed by the freewheeling days of the 1980s, are out and out progressive. A sacred farthest point on home-value getting seemingly makes Texas banks stronger than those of whatever is left of the nation.

Fifth, the present low cost of oil is a result of geopolitics, with Saudi Arabia intending to suffocate Iran in shabby oil. In a Middle East bothered by duplicating clashes, oil markets could flip from shabby to dear in a day.

6th, Texas would be a national financial supernatural occurrence even without oil and gas. Texas is flourishing on the grounds that it keeps a tight rein on the extent of government, accentuating savvy regulation with at least redtape. That is the reason such a large number of organizations like Toyota and Occidental Petroleum are imitating Davy Crockett bycoming to Texas.

However the world cost of oil influences Texas, whatever is left of America may do well to imitate the achievement of its business-accommodating open approaches.

Because of the quickly expanding generation from the Eagle Ford Shale and the Permian Basin, Texas came to another turning point in September, 2013: As a different country, Texas would now rank as the ninth biggest oil creating nation on the planet.

As reported here by Dr. Mark Perry, as per the International Energy Agency (IEA), in the year going before last September, Texas oil generation surpassed that of oil-delivering goliaths like Brazil, Venezuela, Nigeria, Mexico and Kuwait to move into the theoretical Top Ten oil creating countries on earth. Amid September, Texas' oil yield was measured by IEA at 2.7 million barrels for each day. This speaks to a multiplying of the state's every day oil yield in only 29 months. Not since the early years of the twentieth century has the state seen such a quick ascent in its oil yield, and that lofty grade hints at no moderating at any point in the near future.

On the off chance that anything, the blast in West Texas may even quicken in the following couple of years. The early Cline Shale play is starting to warmth up, and results keep on being great in the Wolfberry/Sprayberry and different plays in the Permian. On the off chance that present patterns proceed with, it is likely that Texas would jump past OPEC titans like Iran, Iraq and the United Arab Emirates to turn into what might as well be called the sixth biggest oil creating country throughout the following 12-year and a half.

Percentage of the results this continuous blast in shale oil and common gas generation has delivered:

- The Commerce Department reported as of late that the November U.S. exchange shortage was $34.3 billion, the most minimal month-to-month deficiency in over four years. The single greatest variable, $2.5 billion drop in the estimation of imported oil, made conceivable by the residential oil blast. Unrefined imports were around very nearly $40 billion amid the initial 11 months of 2013, a marvelous decrease amid a time of monetary development.
- This sensational decrease in the exchange deficiency thus drove driving forecasters to essentially raise their projections for how quickly the economy developed in the fourth quarter. Macroeconomic Advisors expanded its gauge from 2.6% to 3.5%, which, if precise, would be the single most noteworthy rate of quarterly financial development since the onset of the Great Recession in 2008.
- Inexpensive and plentiful normal gas is powering an assembling renaissance in the U.S., creating several billions of dollars in new plant and hardware venture, and bringing many thousands well-paying employments back from abroad.
- The U.S. blast has thus fundamentally expanded U.S. worldwide aggressiveness versus Europe, where modern pioneers are in close frenzy at the loss of

employments and venture back over the Atlantic. Germany is in an especially troublesome fix, as it depends on fares for 50% of its yearly GDP, and its vitality expenses stay on an upwards direction because of its wrong-headed over-dependence on non-focused renewable fuel sources like wind and sun powered.

- The U.S. oil blast is additionally having an effect on the geopolitical parity of force. As Daniel Yergin noted on January 9, Iran is all of a sudden considering atomic arrangements important, and that well may not have happened were it not for the blast in shale oil generation in the United States.

- The blast in household oil generation has likewise made another national vitality banter about whether the time has come to rescind the 1970s-period confinements on trading raw petroleum. Some U.S. refiners, whose offices are adapted to refine heavier oils imported from abroad, are discovering themselves overpowered by the increment in light, sweet crudes being created from the Eagle Ford and other shale developments, and a few makers are concerned they will discover getting their item refined at sensible costs progressively troublesome unless they find themselves able to fare some of it to global refining offices. The uplifting news for customers is that this is the sort of verbal confrontation that comes to fruition because of plenitude, not deficiencies like we found in the 1970s.

- In Texas, as we've beforehand noticed, the oil and gas blast, alongside judicious monetary administration by driving policymakers, has in a broad sense changed the state's financial plan picture from one of waiting yearly setbacks to one of relentlessly developing surpluses, alongside a Rainy Day Fund that is reliably filled to the gills.

Yet, plenitude and development bring their own difficulties that must be tended to by groups, policymakers and the business. The effects of the business' overwhelming truck movement remain an issue in South and West Texas, one that every single

intrigued partner are attempting to address. Similarly, there is no doubt that water remains a convincing issue for everybody in these districts, and the business must keep on developing approaches to preserve water and to take advantage of the more bottomless harsh water arrangements that lie underneath the Texas soil. Some late studies have additionally proposed linkage between despicably sited and oversaw saltwater transfer wells and minor tremor action, and the Texas Railroad Commission and administrative pioneers are starting to make solid strides to address this worry.

However, once more, these are all issues that happen because of the monetary development that is created by asset plenitude, and they beyond any doubt beat the sorts of difficulties Texans and all Americans endured amid the oil stuns and asset limitations of the 1970s.

2.5 Oil Transportation and Storage

Transportation and capacity in the oil and gas industry relates to the development of raw petroleum from the oil fields (where oil has been found) to petroleum refineries (where the oil is further handled) to capacity territories, where the petroleum items are put away for appropriation and crisis saves. In its crude state, unrefined petroleum is transported by two essential modes: tankers, which travel interregional water courses, and pipelines where the majority of the oil travels through for at any rate some piece of the course. When the oil has been refined and isolated from characteristic gas, pipelines transport the oil to another bearer or specifically to a refinery. Petroleum items then go from the refinery to advertise by tanker, truck, railroad auto, or more pipelines. Tankers convey petroleum by transporting oil and refined items from different nations to the U.S. to compensate for any shortfall between household items and interest. Tankers likewise transport oil along the Gulf coast. Upgrades in the outline of tankers have brought about the advancement of flexible bearers equipped for transporting a wide

cluster of mass fluid cargoes. Today's tanker vessels, which incorporate both ships and freight boats, are in charge of moving of the unlimited volumes of fluid cargoes.

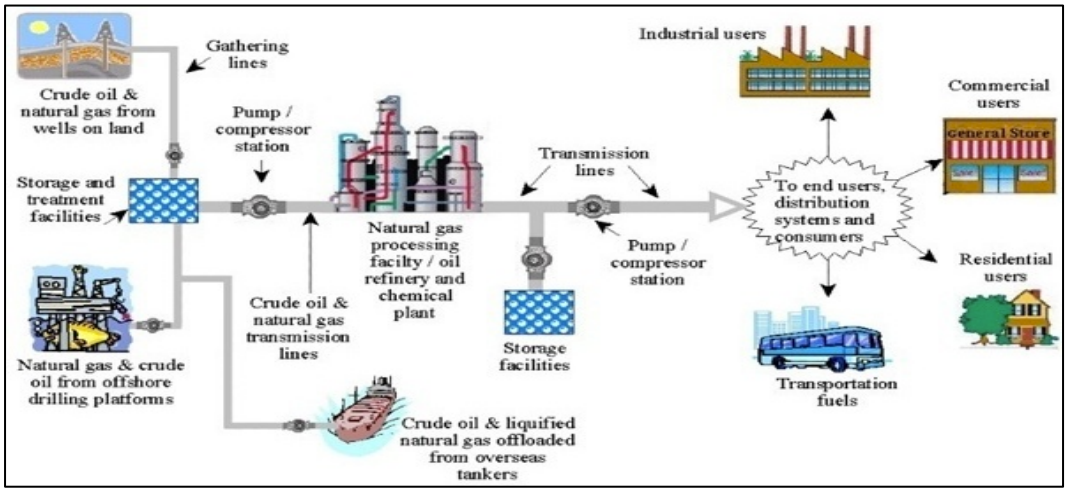

Figure 11 Crude Oil Transportation & Storage

Notwithstanding moving oil from creation to appropriation, the transportation and capacity industry additionally assumes a key part in the arrangement of worldwide oil exchange. As the exchange oil is the biggest class globally, conveying limit permits the transportation business to evaluate what number of tankers are obliged and on which courses. Thus, their related expenses are an essential calculate deciding the example of world exchange.

The transportation and capacity industry is an extremely complex framework that is made out of numerous autonomous proprietors. Case in point, the tanker transportation industry is an exceptionally divided industry with 75 percent of the world tanker armada being autonomously owned.3 In the common gas transport and capacity system, about all is transported through interstate pipelines possessed by no less than 70 to 80 organizations to more than a few hundred underground storerooms.

Accordingly, transportation and capacity speak to a maze of modern procedures that incorporate thorough reviews, stringent measures of agreeability, regulations created from industry activities and government orders for the outline, development and support of tanker armadas and pipelines, and the choice of qualified team and work force. Additionally, wellbeing, effectiveness, tanker structure quality and pipeline respectability are basic concerns, especially as they identify with natural issues, for example, flames, oil slicks, and oil spills. As indicated by Hoovers Oil and Gas Transportation and Storage review, a percentage of the significant players included in oil and gas transportation and capacity are OAO Tatneft, Exxon Mobil Corporation, Royal Dutch Shell, China Petroleum & Chemical Corporation, and BP. These are the same organizations that are likewise included in the refining, showcasing and appropriation of oil and gas.

2.5.1 Oil Tankers

Tankers travel interregional watercourses. Tankers are basically the significant haulers of oil that is transported in into the United States. The U.S. Coast Guard characterizes a tank vessel as one that is built or adjusted to convey oil or perilous material in mass as payload or freight buildup. The most punctual development of tank vessels utilized single bodies.

There are different sorts of tankers: oil tanker, package tanker (concoction vessels), blend bearer (intended to convey oil or strong cargoes in mass), and flatboats. Moreover, there are universal mass compound codes overseeing the sheltered transport of synthetic cargoes giving different levels of insurance against the uncontrolled arrival of substances that represent the best natural danger.

Figure 12 Crude Oil Tanker

Tank vessels are ordered by the exchange, which they routinely work more than a time of time. The three most normal classes are unrefined petroleum transporters, item bearers: which can convey clean (e.g., gas, plane fuel) and filthy (e.g. dark oils): and bundle bearers (chemicals). Tankers have a tendency to stay in one exchange yet economic situations can manage a change, despite the fact that the procedure to change a vessel's exchange includes broad work.

Rough bearers are classed as either VLCCs (Very Large Crude Carriers) or ULCCs (Ultra Large Crude Carriers) and are intended to transport tremendous amounts of raw petroleum over numerous long and vigorously voyaged ocean courses. The proper economies of scale rely on upon the territory from which the oil is being dispatched. Moreover, "lightering," offloading or exchanging oil from expansive tankers to littler ones, a procedure which can move 1,000 barrels for every hour: is utilized so that the littler vessels can enter littler ports that the bigger vessels can't.

Generally, the majority of the country's tanker armadas were constructed as single-structure vessels, i.e., a solitary layer of steel made up the frame. As boats and canal boats are a noteworthy connection in the nation's oil transportation system, both for transporting unrefined petroleum to U.S. refineries and for transporting refined oil items to showcase, the Oil Pollution Act (OPA) of 1990 rolled out broad improvements intended to make these shipments earth more secure. One change obliges the eliminating of all shipment of oil cargoes in single-frame vessels in U.S. waters from 1995 to January 1, 2015, with the most seasoned and biggest vessels eliminated first. After January 1, 2015, just twofold body vessels may be utilized. There are likewise European guidelines here with the Regulation of the European Parliament and of the European Council/Commission on Legislative Documents changing Regulation EC No. 417/2002 on the quickened staging in of twofold structure or identical outline prerequisites for single-body oil tankers.

One of the significant concerns in the sheltered transport of mass fluid loads by tank vessel is the weight on the structure. Twisting as hanging (centralization of weight in the mid area of the vessel bringing on the deck to be subjected to pressure strengths while in the meantime the bottom is under strain), hoarding (amassing of weight at both closures of the vessel creating the deck to encounter elastic powers while the bottom is under pressure), and shear power, which happens when two powers demonstration in inverse headings parallel to one another, for example, at a bulkhead between a void stabilizer tank and a full payload tank. The weight or gravitational and light activity experienced on either side of the bulkhead causes the shear power marvel.

The advancement of the super tanker came to fruition because of a variety of components including Middle East threats that prompted the conclusion of the Suez Canal, nationalization of oil fields in the Middle East, and solid rivalry among universal

boat proprietors. VLCCs and ULCCs spread the most lone exchange courses, regularly stacking at seaward stages or single-point moorings and releasing at assigned lightering zones off the coast.5 As the interest is expanding for more unrefined petroleum and as more oil stores are being found and grew in different regions, for example, the Caspian Basin, Latin America and the Middle East, the requirement for more tankers has developed.

2.5.2 Pipelines

Pipelines assume an extremely discriminating part in the transportation process on the grounds that the majority of the oil travels through pipelines for in any event some piece of the course. After the raw petroleum is isolated from normal gas, pipelines transport the oil to another transporter or specifically to a refinery. Petroleum items then go from the refinery to advertise by tanker, truck, railroad tank auto, or pipeline. Pipelines are additionally basic for landlocked crudes furthermore supplement tankers at certain key areas by easing bottlenecks or giving easy routes. The main interregional exchange that as of now depends singularly upon oil pipelines is in the middle of Russia and Europe.

Subsea pipeline designs frequently say "Nothing happens until we get our lines set up." Indeed, it is significant that oil and gas are transported from the supply to a refinery through a procedure that includes the liquids spilling out of the wellhead through a jumper to a complex. From the complex, the admixes liquids travel through a flow line which could be up to 70 miles or more for gas and 10-20 miles for oil, to a creation riser. That line moves the liquids to a creation stage where preparing happens. Outbound from the stage the liquids travel through a fare riser to a subsea pipeline and on to shore.

Figure 13 Crude Oil Pipeline

Pipelines can range up to 36 inches (92cm) in distance across and considerably bigger, with a percentage of the biggest pipelines conveying more than one million barrels of oil every day. Pipelines cross a wide range of regions and in all parts of the world. They are joined utilizing an electric bend welding procedure grew around 1928. They are constructed to withstand a lot of weight of 1,000 pounds for each square creep and overwhelming obligation machines are in charge of fitting them inside of the shapes essential for their laying in a wide range of landscape. Key arranging includes deciding the briefest and most efficient courses where they are assembled, the quantity of pumping stations and normal gas pressure stations along the line, and terminal storerooms so that oil from any field can be delivered to any refinery on interest. Consideration is likewise taken in the checking and development for pipelines in light of ecological and wellbeing issues. Case in point, one worry is to keep away from the potential for flames and blasts in the offloading of unrefined petroleum by funnels onto tankers for transport to a refinery.

Subsequently, guidelines exist for pipelines in the territory of wellbeing in the outline and development of pipelines. In an article in the September 12, 2005, issue of Oil and Gas Journal entitled, "The Rising Pressure for Pipeline Integrity," pipeline trustworthiness is characterized as a sub-industry of administrative controls that must oversee the world's pipeline foundation. Norms, for example, the "Global Organization for Standardization (ISO) 15649: 2001 Petroleum and Natural Gas Industries: Piping," is a universal standard that indicates the prerequisites for configuration and development of funneling for the petroleum and regular gas commercial ventures, and the American Petroleum Institute. Repairing unrefined petroleum, condensed petroleum and item pipelines R(1999) reflect industry activities because of the needs around there.

The American Petroleum Institute issues pipeline direction to U.S. pipeline administrators to enhance open attention to pipelines. The motivation behind the rules known as Recommended Practice 1162 or Public Awareness Programs for Pipeline Operators is to lessen mischances, regularly owing to burrowing by property holders, builders and ranchers. Pipeline organizations conduct open mindfulness programs yet the government Pipeline Safety Improvement Act of 2002 built up new models. RP1162 is intended to help organizations meet these new gauges. In get ready RP1162, the American Petroleum Institute teamed up with government and state controllers, normal gas and fluid transmission organizations, and nearby appropriation companies.8 The U.S. Statistics Bureau appoints the accompanying NAICS codes to the Pipeline Transportation industry:

Universally, the Baku-Tbilisi-Ceyhan (BTC) pipeline on the shoreline of the Caspian Sea is the first pipeline from this zone whose stream of oil at first occurred on Wednesday, May 25, 2005. It was a $3.2 billion base disputable venture that started verbal confrontation for a long time. This new United States upheld pipeline is seen as a

key to diminishing the West's dependence on Middle East oil. The Caspian fields are assessed to hold the world's third-biggest reserves.9 Russia start development on the first leg of its arranged 4,130-km raw petroleum pipeline from Taishet in eastern Siberia to the Sea of Japan. It will cross seven regions of the Russian Federation. Indonesia additionally plans to construct a 1,200km pipeline from the regular gas handle in East Kalimantan to Java at an expense evaluated to be $1.2 billion.

2.5.3 Tank Trucks/Railroad Tank Cars

Numerous petroleum items fly out from refineries to showcases by tank truck or railroad tank auto. Tank trucks convey fuel to administration stations and warming oil to houses. These trucks can convey up to 300 barrels of fuel. Railroad tank autos can run in limit from around 100 to more than 1,500 barrels of oil. Likewise, there are wide ranges of transportation segments that are in charge of transporting oil items. For instance, these incorporate pipelines, makers, refiners, terminal administrators, autonomous advertisers or regular transporters that may have no association with the oil business aside from that they send the oil item from one area to another.

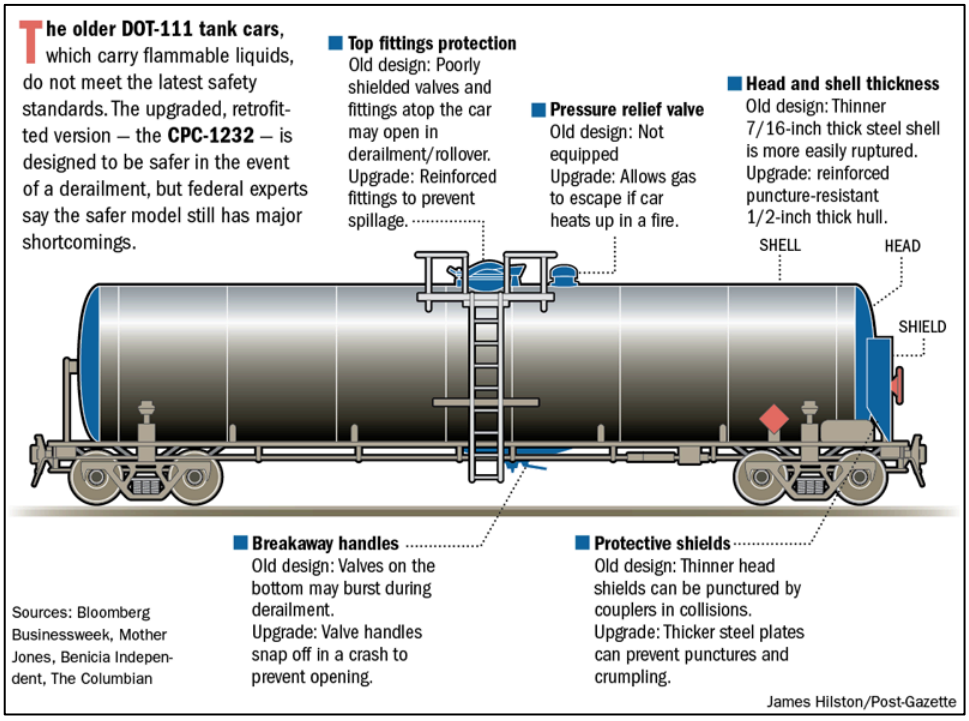

Figure 14 Crude Oil Rail Car

2.6 Role of Pipelines

While iron channel for different uses in the U.S. goes back to the 1830s, the utilization of channel for oil transportation began not long after the boring of the first business oil well in 1859 by "Colonel" Edwin Drake in Titusville, Pennsylvania.

The principal funnels were short and fundamental, to get oil from drill openings to close-by tanks or refineries. The quick increment sought after for a valuable item, in the early case lamp fuel, prompted more wells and a more noteworthy requirement for transportation of the items to advertises. Early transport by teamster wagon, wooden pipes, and rail quickly prompted the improvement of better and more pipes and pipelines.

In the 1860s as the pipeline business developed, quality control of funnel assembling turned into a reality and the quality and sort of metal for channels enhanced from fashioned iron to steel.

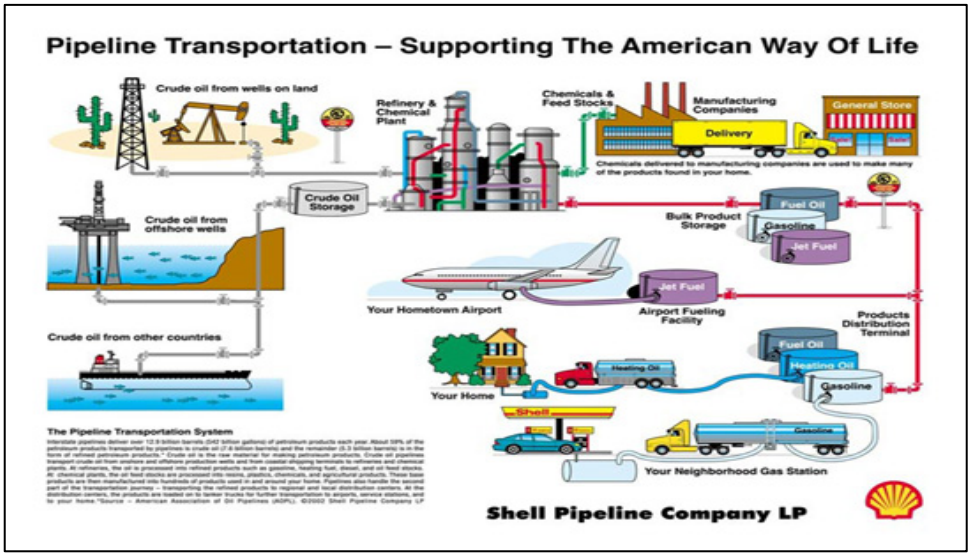

Figure 15 Pipeline Transportation

Innovation keeps on improving funnels of better steel, and discover better approaches to introduce pipe in the ground, and constantly break down its condition once it is in the ground. In the meantime, pipeline wellbeing regulations turn out to be more finish, driven by better comprehension of materials accessible and better methods to work and look after pipelines.

They keep on assuming a noteworthy part in the petroleum business giving sheltered, solid and prudent transportation. As the requirement for more vitality increments and populace development keeps on making tracks in an opposite direction from supply focuses, pipelines are expected to keep on bringing vitality.

From the beginning of wooden trenches and wooden barrels, the pipeline business has developed and utilized the most recent innovation in pipeline operations and upkeep. Today, the industry uses refined controls and PC frameworks, propelled funnel materials, and erosion anticipation strategies.

There are two general sorts of vitality pipelines – fluid petroleum pipelines and regular gas pipelines.

Inside of the fluid petroleum pipeline arrange there are raw petroleum lines, refined product offerings, very unpredictable fluids (HVL) lines, and carbon dioxide lines (CO2). Unrefined petroleum is additionally subdivided into' 'Social affair Lines' and 'Transmission Lines".

Initially, assembling lines are little pipelines for the most part from 2 to 8 inches in distance across in the zones of the nation where unrefined petroleum is discovered profound inside of the earth. These social affair lines exist everywhere throughout the nation yet the main part of them are found principally in Texas, North Dakota, California, Oklahoma, New Mexico, Louisiana, and Wyoming with little frameworks in various other oil delivering states.

The bigger cross-country raw petroleum transmission pipelines or trunk lines convey raw petroleum from delivering territories to refineries. There are give or take 55,000 miles of unrefined petroleum trunk lines (normally 8 to 24 inches in width) in the United States that associate local markets. There are likewise a couple of VERY substantial trunk lines. One of the biggest in the U.S. is the Trans-Alaska Pipeline System, which is 48 inches in breadth.

The following gathering of fluid petroleum pipelines is one that conveys refined petroleum items – gas, plane fuel, home warming oil and diesel fuel. These refined item pipelines differ in size from generally little, 8 to 12 inch measurement lines, to much

bigger ones that go up to 42 inches in width. There are give or take 95,000 miles of refined items pipelines across the nation. They are found in every state in the U.S. These pipelines convey petroleum items to vast fuel terminals with capacity tanks that are then stacked into tanker trucks. Trucks cover the last couple of miles to make nearby conveyances to service stations and homes. Significant commercial ventures, airplane terminals and electrical force era plants are supplied specifically by pipeline.

Profoundly unstable fluid (HVL) lines and carbon dioxide (CO2) lines are likewise a piece of the fluid petroleum pipeline system. These fluids swing to gas once presented to the environment. They incorporate ethane, butane and propane. Carbon dioxide pipelines permit carbon dioxide to improve oil recuperation, as CO2 has long done in North America.

The regular gas pipeline framework is composed fairly in an unexpected way. Characteristic gas, dissimilar to oil, is conveyed specifically to homes and organizations through pipelines.

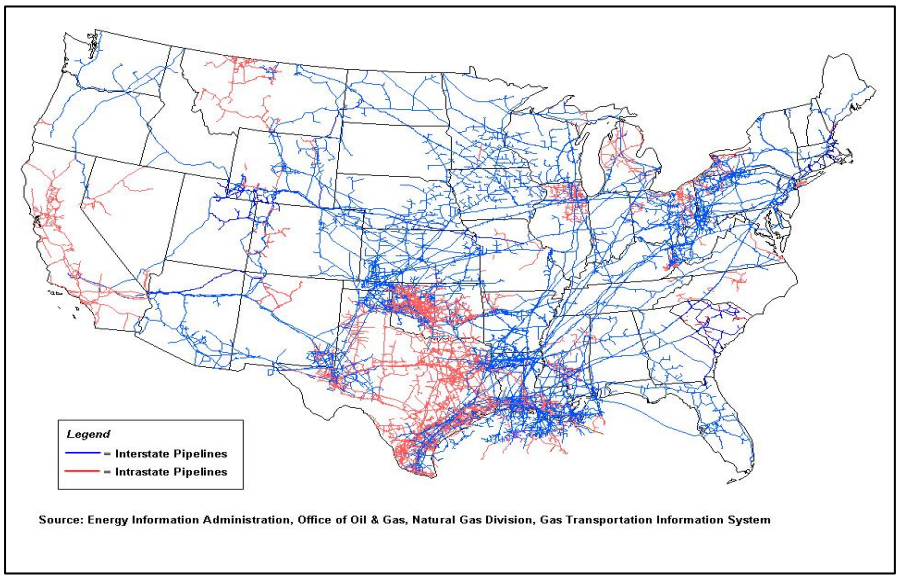

Figure 16 Pipeline Network in the US

Natural gas can contain natural gas fluids (NGL) when delivered. Processors uproot water, NGLs, and polluting influences from the normal gas stream to lake the characteristic qas suitable available to be purchased. Characteristic gas and NGLs then go on independent pipeline frameworks. It is resolved to be rich or wet on the off chance that it contains significant regular gas fluids (NGL); by complexity, normal gas is known not incline or dry in the event that it doesn't contain these fluids.

The U.S. characteristic gas pipeline system is an exceptionally coordinated transmission and circulation framework that can transport normal gas to and from about any area in the 48 states. It comprises of more than 210 regular gas pipeline frameworks. This records for 305,000 miles of interstate and intrastate transmission pipelines.

Most gallons of fuel move far by pipeline and a short path by truck. After a gallon of fuel is refined from unrefined petroleum, it goes into a pipeline alongside a huge number of different gallons, and is moved the long separation from a refinery, say one in Texas, to an appropriation terminal in a noteworthy city, as Memphis, Tennessee. So first the gallon moves 600 miles by pipeline, then a truck grabs that gallon alongside around 8,000 more and moves it the last 20-30 miles to a neighborhood corner store.

Another case is home warming oil that is likewise delivered at a refinery in Texas and moves more than 1,000 miles to Linden, New Jersey. There it is stacked onto a scow and taken to Portland, Maine to a dispersion terminal where that gallon makes its last trek of 10-30 miles by truck to a mortgage holder's fuel oil tank.

These are cases of the coordinated way of the petroleum dispersion organize in the U.S. Taking a gander at all systems for transportation and the relative separations every takes, to transport a solitary gallon, pipelines move the larger part – 70% of all petroleum transportation.

Chapter 3

Methodology

3.1 Description

This research creates a mixed-integer programming (MIP) baseline model and a frontier curve which includes sampling plan for the cost of oil transportation and the proportion of oil flow through various oil production districts to oil refineries in Texas. This particular research uses Microsoft Excel Solver as the primary tool to reach to the optimal solutions. The crude oil supply chain data in Texas is obtained from the US Energy Information Administration (EIA) website majorly and various other sources.

This research enlightens whether or not the flow distribution of oil through pipelines will impact the overall cost and profit of the major oil refineries of Texas.

To compare the impacts of flow distribution through pipeline on the oil transportation, we need to come up with a standard distribution model.

3.2 Hypothesis statement

H_0: The flow distribution of oil through pipeline will not impact the supply chain cost or profit.

H_1: The flow distribution of oil through pipeline will impact the supply chain cost or profit.

The rejection region for H_0 is confirmed or the H_0 is rejected for the hypothesis statement if the flow distribution of oil through pipeline impacts the supply chain costs by more than fifteen percent (15%).

In this research, the distribution center (DC) model example printed in the “Modeling The Supply Chain” textbook by Shapiro is used to show the ideal locations for the oil producing districts in Texas which depends upon the transportation distances,

associated transportation cost and the capacity of the oil producing districts. The model is then optimized in Microsoft Excel using GRG Non-Linear engine in solver to minimize the objective function. The objective function is then solved based upon the oil transportation cost, the fixed cost for setting up the pipeline and maintaining the pipeline and the variable cost for setting up the pipeline and maintaining the pipeline. Several scenarios are then run that change the variable cost and the fixed cost to evaluate the impacts of share of pipeline in oil transportation on the total cost and the profit. The different scenarios are listed below in Table 1.

Table 1 Scenarios 1-4

SCENARIO	LEVEL	SCENARIO DESCRIPTION
1	25%	25% OF THE TOTAL OIL TRANSPORTED WILL MOVE THROUGH PIPELINE
2	50%	50% OF THE TOTAL OIL TRANSPORTED WILL MOVE THROUGH PIPELINE
3	75%	75% OF THE TOTAL OIL TRANSPORTED WILL MOVE THROUGH PIPELINE
4	100%	100% OF THE TOTAL OIL TRANSPORTED WILL MOVE THROUGH PIPELINE

The major oil-producing districts in Texas are numbered in Table 2.

Table 2 Oil producing districts numbering

i	OIL PRODUCING DISTRICTS
1	SAN ANTONIO
2	JACKSON
3	MIDLAND

The oil producing districts listed in Table 2 are the 3 of the 13 oil-producing districts in Texas. These 3 districts produce roughly 70% of the total oil extracted in Texas.

The major oil refineries in Texas are numbered in Table 3.

Table 3 Oil refineris numbering

j	OIL REFINERY
1	BEAUMONT REFINERY
2	BAYTOWN REFINERY
3	EL PASO REFINERY
4	PORT ARTHUR REFINERY
5	TOTAL PORT ARTHUR REFINERY
6	VALERO HOUSTON REFINERY

The oil refineries listed in Table 3 contribute 42% of the oil produced from the refineries in Texas.

The scenarios that were run are listed in Table 4.

Table 4 Scenario Summary

OIL PRODUCTION DISTRICT	TRANSPORTATION SHARE	SCENARIO
SAN ANTONIO	25%	1
	50%	2
	75%	3
	100%	4
JACKSON	25%	1
	50%	2
	75%	3
	100%	4
MIDLAND	25%	1
	50%	2
	75%	3
	100%	4

The screenshot in Figure 17 below shows the distance and the cost per mile from the major oil producing districts to the refineries located across Texas and the cost ($/mile/barrel) associated with transporting oil from the districts to the refineries listed.

	FROM PRODUCTION FIELD TO REFINERY	Beaumont Refinery	Baytown Refinery	El Paso Refinery	Port Arthur Motiva Refinery	Total Port Arthur Refinery	Valero Houston Refinery
DISTANCES	MIDLAND	561	500	292	564	569	297
	SAN ANTONIO	282	221	552	285	291	503
	JACKSON	188	128	695	191	197	622
PIPELINE COSTS/MILE	MIDLAND	3.28	3.26	3.5	3.23	3.2	3.54
	SAN ANTONIO	3.53	3.59	3.21	3.56	3.57	3.19
	JACKSON	3.62	3.67	3.15	3.71	3.69	3.19

Figure 17 Distance & cost of transportation

The screenshot in Figure 18 shows the fixed cost and variable costs of transporting oil through the pipelines from the respective oil producing districts to the refineries listed. The figure also shows the total capacity of each refinery (Last row), the maximum limit of oil (Barrels) a refinery can process.

	B	C	D	E	F	G	H
17		Beaumont Refinery	Baytown Refinery	El Paso Refinery	Port Arthur Motiva Refinery	Total Port Arthur Refinery	Valero Houston Refinery
18	FIXED COST	290000	260000	286000	315000	239000	421000
19	VARIABLE COST	20	31	38	35	19	28
20	SELECTION	1	1	0	1	0	0
21	FIXED COST	182000	166000	190000	210000	200000	199000
22	VARIABLE COST	22	22	15	19	24	13
23	SELECTION	0	1	1	0	0	0
24	FIXED COST	256000	250000	231000	258000	259000	225000
25	VARIABLE COST	24	23	19	21	20	18
26	SELECTION	0	0	1	1	1	1
27	**CAPACITY**	344,500	572,500	125,000	600,000	232,000	145,000

Figure 18 Fixed & Variable costs

Fixed cost includes the pipeline construction cost and the materials cost.

Variable cost includes freight, engineering and labor.

The screenshot in Figure 19 shows the flow table that is solved by the Excel solver using GRG Non-Linear method. Column I shows the total flow out from the oil producing districts. Row 37 shows the total amount of oil that can be transported to the refineries (When the refineries are running at 80% capacity).

	B	C	D	E	F	G	H	I	J	K	L
33		Beaumont Refinery	Baytown Refinery	El Paso Refinery	Port Arthur Motiva Refinery	Total Port Arthur Refinery	Valero Houston Refinery	FLOW OUT			TRANSPORTATION COST
34	SAN ANTONIO	275600	46282	0	197874	0	0	519756	<=	592687	511831412.4
35	JACKSON	0	411718	0	0	0	0	411718	<=	411718	193408647.7
36	MIDLAND	0	0	100000	282126	185600	116000	683726	<=	683726	1076055137
37	FLOW IN	275600	458000	100000	480000	185600	116000				
38		<=	<=	<=	<=	<=	<=				
39	**CAPACITY**	344,500	572,500	125,000	600,000	232,000	145,000				
40		>=	>=	>=	>=	>=	>=				
41	**DEMAND**	275,600	458,000	100,000	480,000	185,600	116,000				
42							**TOTAL FLOW OUT**	1615200		**TOTAL COST**	1781295197

Figure 19 Flow out distribution

The screenshot in Figure 20 shows the total capacity and cost according the scenarios. The flow in row 52 shows the total flow in particular refinery according to the scenario. And the row 53 shows the total cost per refinery in transporting the total oil over

the total distance. This includes the fixed cost, the variable cost per mile, and the flow out, all according to the selection.

	B	C	D	E	F	G	H
52	FLOW	275600	252141	25000	268405.5	46400	29000
53	COST	5802000	6389640	896000	8979751.5	1187000	747000
54							
55		275600	252141	25000	268405.5	46400	29000
56		<=	<=	<=	<=	<=	<=
57		344,500	572,500	125,000	600,000	232,000	145,000

Figure 20 Capacity and cost

For the objective function, Eq. (1) was derived:

$$Min: \Sigma_{i \to 3}\Sigma_{j \to 6} A_{ij}X_{ij}Y_{ij} + \Sigma_{i \to 3}\Sigma_{j \to 6} B_{ij}Y_{ij} + \Sigma_{i \to 3}\Sigma_{j \to 6} C_{ij}X_{ij}Y_{ij} \quad (1)$$

Where:

A_{ij}= Total pipeline costs from district *I* to refinery *j*

B_{ij}= Fixed costs from district *i* to refinery *j*

C_{ij}= Variable costs from district *i* to refinery *j*

i= The oil district from where the oil is extracted

j= The refinery where the oil is shipped

X_{ij}= The number of barrels of oil shipped from district *i* to refinery *j*

Y_{ij}= The binary selection of moving oil from field *i* to refinery *j*

Table 2 and Table 3 identify the *i* and *j* values for each of the oil districts and the refineries in Texas.

The following equations were used as constraints to ensure that the model runs perfectly:

$$\Sigma_{i \to 3} X_{ij} \leq D_j \quad (2)$$

Where D_j is the total capacity of refinery j.

$$\Sigma_{i \to 3} X_{ij} \geq O_j \qquad (3)$$

Where O_j is the operating capacity of refinery j. Here we have assumed that the refinery j is operating at 80% of its total capacity.

$$\Sigma_{j \to 6} X_{ij} \leq F_i \qquad (4)$$

Where F_i is the total flow of oil producing district i.

Using a binary constraint, the selection of oil producing districts for each oil refinery is done. The demand of some oil refineries cannot be fulfilled by the production of single oil producing district therefore we use the selection constraint:

$$Y_{1j} + Y_{2j} + Y_{3j} \leq 2 \qquad (5)$$

A snapshot of the Microsoft Excel model is given below.

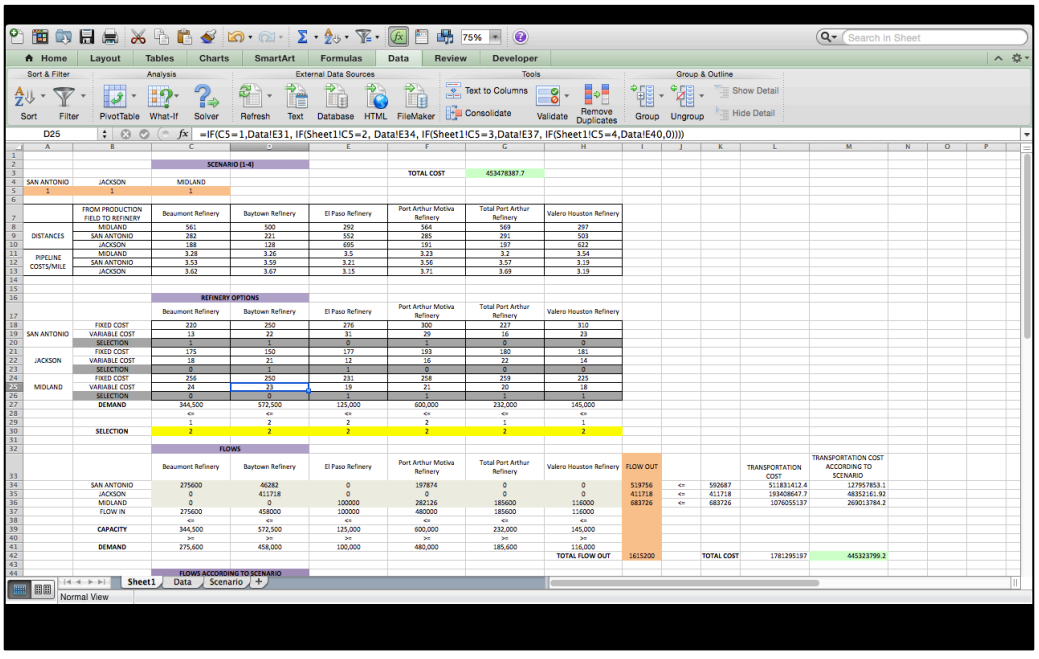

Figure 21 Snapshot of the Excel Model

The Excel model is used to minimize the total cost i.e. cell G3. All the different scenarios are plugged in the Excel programming and users can toggle it to have the minimum cost. The users can change the variable cost and the fixed cost also.

The objective function G3 is the sum of M42 (Transportation cost) and M53 (Refinery setup cost). The selection of the oil producing districts for particular refineries is decided based upon the binary variables C20:H20, C23:H23, C26:H26.

Chapter 4

Results

The objective of this dissertation is to see if the supply chain costs of the Texas oil and gas industry can be minimized by introducing a mixed-integer programming (MIP) model that can improve the supply chain quality of crude oil. In order to meet the objective, evaluate the economic impacts of pipeline infrastructure (quality) and refinery capacity (Flow) on the supply chain network. The results of the objective are below.

Table 5 Cost of transportation from San Antonio

Flow Level percent	**Supply Chain Costs USD**
25	131312690.6
50	262470278.2
75	394281751.3
100	526568744.4

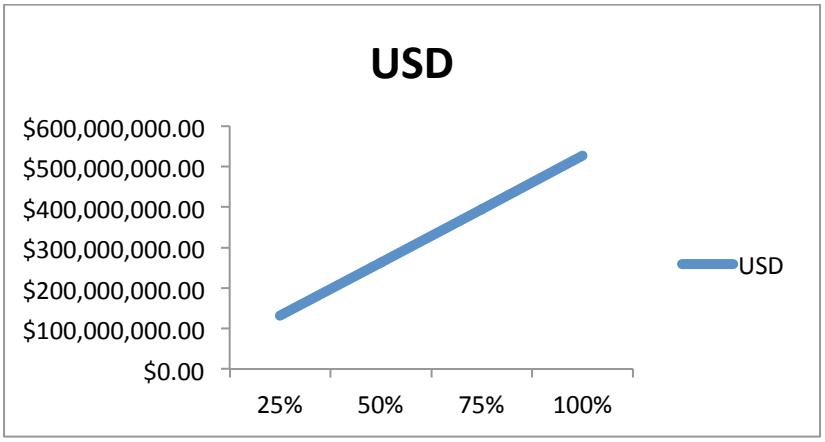

Figure 22 Frontier Curve for San Antonio

Table 6 Cost of transportation from Jackson

Flow Level percent	Supply Chain Costs USD
25	50840681.42
50	101589221.8
75	153164198.3
100	204074597.7

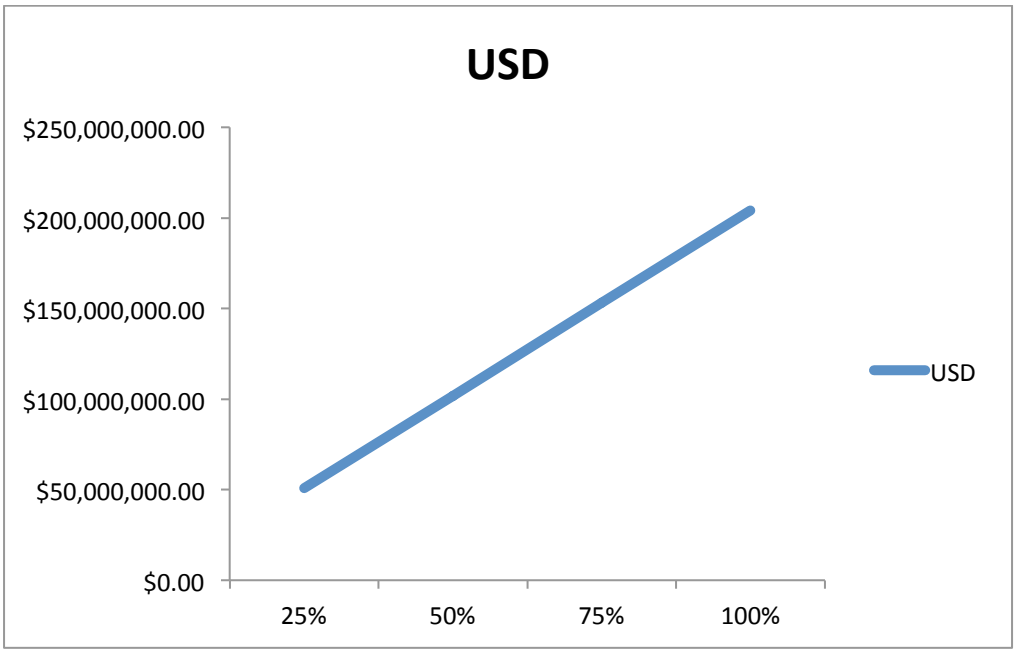

Figure 23 Frontier Curve for Jackson

Table 7 Cost of transportation from Midland

Flow Level percent	Supply Chain Costs USD
25	273392945.7
50	546301554.4
75	820383015
100	1095876739

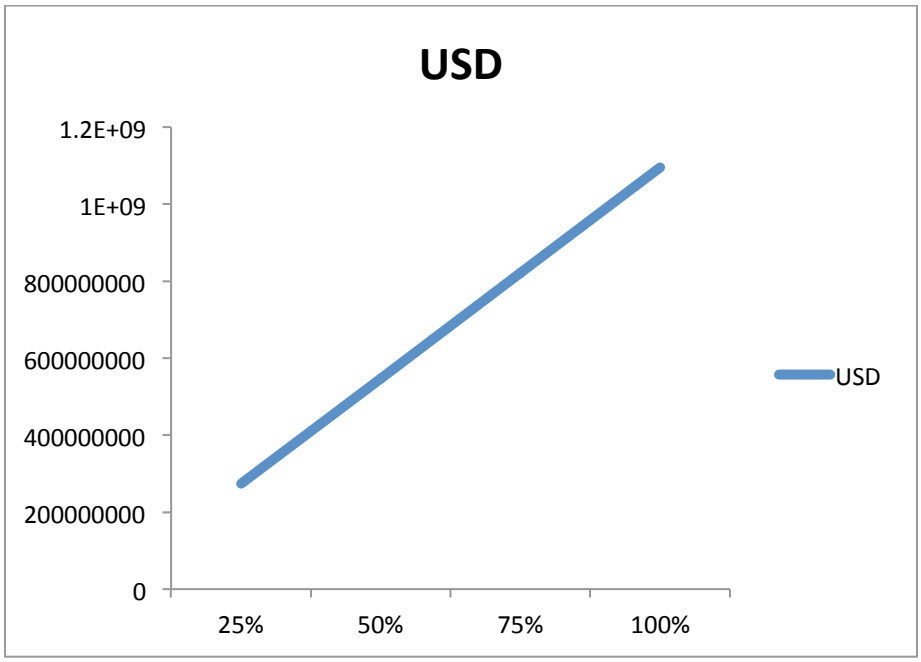

Figure 24 Frontier Curve for Midland

Chapter 5

Contribution to the Body of Knowledge

5.1 Conclusion

As indicated by the insights Texas has expanded its reliance on unrefined petroleum and petroleum items assets from different nations by more than 20 percent. The criticalness of this exposition is to look for the effects of the use of pipeline as a method of transportation on the store network cost or the transportation cost. The issue here is fathomed by presenting a blended – Mixed Integer Programming (MIP) model. The more extensive effects are whether recognizing the conceivable ventures for the future worldwide production network of unrefined petroleum needs can upgrade the store network.

What happens to the Texas oil and gas store network when the transportation mode is changed? More than a time of time, the Texas oil and gas store network has seen an expanding request in the raw petroleum. Today, we confront a question that if the present productions network system can deal with the expanding interest of unrefined petroleum. The state confronts the case if the present pipeline and the refinery limit can deal with the developing interest. "Is it monetarily advantageous to put resources into the store network nature of raw petroleum for Texas?" Hypothesizing that the pipeline base will affect unrefined petroleum production network costs, and recommends what will give us the base inventory network cost.

5.2 Limitations and Area of Disciplines

There are barriers for this dissertation, for example, the accessibility of information and the extent of the thesis. The association of Petroleum Exporting Countries (OPEC), United States of Energy Information Administration (U.S. EIA), Ministry of Petroleum and Natural Gas of US gave helpful information and certainties about the Indian Oil Industry. This thesis is essentially centered around the local Texas Oil industry store network because of extremely restricted information and data on the inventory network and the expense included. This paper is centered on just three of the generation units and just seven oil refineries spread over the state. In this manner, the extent of the paper is sufficiently expansive to consider the way of the inventory network exercises over the whole local unrefined petroleum store network. Likewise the import of raw petroleum and the fare of refined petroleum items can be taken into thought to measure the general worldwide production network for US. Future fill in as a continuation of this thesis can be proposed when we incorporate the whole production network of US considering the household and universal business sector.

A few modern building controls are incorporated in this dissertation like enhancement procedure, production network administration (SCM) applications. Streamlining system is utilized to create and asure the blended whole number programming model that will characterize how the pipeline method of transportation to supply unrefined petroleum from the chosen oil generation units to the refineries and figure the transportation/store network cost. The Supply Chain Management application clarifies how the oil supply functions the development of oil from where it is created, to where it is refined and finally where these items are sold.

5.3 Intellectual Merit and Broader Impact

The intellectual merit of this dissertation is a mixed – integer-programming model that will help us in determining the supply chain cost of the domestic oil distribution from the production sites to the refineries. Furthermore, the broader impacts of this dissertation are to look in how the future investments showed and can be made to optimize the countries supply chain for future.

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Biographical Information

Jashandeep Singh was born in Haryana, India. He came to the United States as an international student to pursue his Masters in Industrial Engineering. He did his bachelors in Mechanical Engineering and it was during his internship in 'Lean/Process Improvement' department, that he got inclined towards Industrial Engineering. During his undergraduate studies, he interned twice for 'JBM Auto Ltd.', an ancillary unit of Suzuki Motors, India.